MEKELLE UNIVERSITY

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The Impact of Small-Scale Irrigation on Rural household Food Security

(The case of Emba Alaje woreda)

By:

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Declaration

I, Muez Haileleul Aregawi, hereby declare that this thesis work entitled " The impact of small-scale irrigation on rural household food security in southern Tigray Zone: (Evidence from Emba Alaje Woerd Woreda)"Submitted by me in partial fulfillment of the requirements for the award of the degree of Master of Science in Economics(Development policy analysis) to the College of Business and Economics, Mekelle University, through the Department of Economics, is original work carried out by himself. The matter embodied in this thesis work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief. Where other sources of information have been used, they have been duly acknowledged.

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Certification

This is to certify that this Thesis work entitled **“**The impact of small-scale irrigation on rural household food security (Emba Alaje Woreda, Tigray, Ethiopia**)”** Submitted in partial fulfillment of the requirement for the award of the degree of Master of Science in Economics(Development Policy Analysis) to the College of Business and Economics, Mekelle University, through the Department of Economics (Development Policy Analysis) to the college of Business and Economics, Mekelle University, through the Department of Economics, done by Muez Haileleul I.D No CBE/Ps/021/03 is an original work carried out by himself. The matter embodied in this Thesis work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief. Where other sources of information have been used, they have been duly acknowledged.

Advisor: Kidanemariam Gebregziabher (PhD) Signature ____________date____________

Co-advisor: Menasbo Gebru (Ass.Pro) Signature_______________ date_________________

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DEDICATION

I dedicated this thesis document to my Mother, brothers and sisters for tending me with love and for their wholehearted partnership in the success of my life.

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ADLI	Agricultural Development Led Industrialization
PA	per adult equivalent
BOARD	Bureau of Agriculture and rural development
CSA	Central Statistics Agency
DAs	Development Agents
ETB	Ethiopian Birr
FAO	Food and Agricultural Organization
GDP	Gross Domestic Product
HHs	Household Heads
IWRM	International Water Resource Management
IFAD	International Fund for Agricultural Development
IWMI	International Water Management Institute
Km	Kilometer
LDC	Less developed countries
LR	Likelihood Ratio
MOARD	Ministry of Agriculture and Rural Development
MOFED	Ministry of Finance and Economic Development
MOWE	Ministry of Water and Energy
NGOs	Non- Governmental Organizations
NMTIP	National Medium-Term Investment Program
OLS	Ordinary Least Squares
PSNP	Productive Safety Net Program
SNNPR	South Nation, Nationalities and Peoples Region States
TLU	Total livestock unit
UNDP	United Nation Development Program
VIF	Variance Inflation Factor
WOBAD	Woreda Bureau of Agricultural and Development
WFED	Woreda Finance and Economic Development
WFP	World Food Program
WWME	Woreda Water and Mineral Energy

ABSTRACT

In Ethiopia, agriculture is the primary determinant of economic growth and reducing level of poverty because it has the largest component of the economy. Farming irrigation also has both direct and indirect impact on food security and it is one of the most important rural development strategies. Food security becomes as a result of economic growth. The purpose of this research is to assess the impact of small-scale irrigation in ensuring rural households food security based on data collected from 150 farmers in Emba Alaje Woreda Tigray Regional state; Ethiopia. Descriptive statistics and Heckman's two-stage estimation were used to estimate determinants of small-scale irrigation participation and household food consumption expenditure. The study findings indicate that sex, education level, cultivated land, distance to FTC, access to extension services, access to credit and water availability were the determinant households' participation in small-scale irrigation where as household size, cultivated land, soil fertility, total livestock household consumption. The Foster Greer Thorbecke (FGT) explains that irrigation participants are better-off than non-participant. That is poverty indices was lower among irrigation participants compared to non-participants, with 35.5% of non-participants classified as poor compared to 26.3% of irrigation participants. In the same way the main findings of the research indicates that irrigation access enabled the sample households to grow crops more than once a year; to insure increased stable production, income and consumption. The study concludes that small-scale irrigation is one of the viable solutions to secure household food needs in the study area but it did not remove the food insecurity problem and recommends that investments in small-scale irrigation continue for poverty reduction.

Key words: - Food security, FGT, Heckman two stage model, Emba Alaje.

Chapter one: Introduction

1.1Background of the study

Ethiopia is one of the poorest countries in the world, where about 29.2% of its population is living below poverty line (CIA world Fact book, 2013). Even if poverty is common for both urban and rural areas, it is mostly familiar with in the rural part of the country. For example, in 2009, Ethiopia was ranked 171th out of 182 countries on the UNDP Human Development Index result (Demese et al., 2009).

In Ethiopian, most of the population lives in rural areas where about 95% of the agricultural product is produced by smallholder farmers (MoARD, 2010). Agriculture is the backbone of the Ethiopian economy as it accounts for about 80% of the population directly or indirectly involved in it. This implies that it is the dominant sector for GDP contribution. For example in 2011, agriculture contributed to national GDP (40%), employment (80%), supply of raw materials (70%), government tax revenue (28%) and export earnings (85%). However, because of small and fragmented landholding, dependence on natural factors of production, environmental degradation, population growth, low access to new agricultural technologies, traditional methods of cultivation, and low institutional support services, it is largely based on subsistence farming (MoFED, 2012).

To address subsistence farming problem, the economic performers designed a national strategic plan in 1991, Agricultural Development Led Industrialization (ADLI) that gives focus on irrigation, cooperative societies and agricultural technologies to answer the food demand and bring socioeconomic development in the country. Small scale irrigation development is one of the policies within this strategy. The success full history of Asian countries for instance China in the 1960s and 1970s in accommodating the growing population, achieving rapid economic growth and increasing employment through irrigated agriculture and eager the Ethiopian government to give more weight to the development of irrigation scheme (Bacha et al. 2011). Based on this, the federal and the regional governments associated with other international and local NGOs have significantly supported to rural farmers to participate and use irrigation farming. As a result, the irrigated farmland, irrigation production and the number of irrigation farmers in the country have notably increased, up to 80%, between 1990 and 2010 (CSA, 2012).

Irrigation is one of the agricultural technologies defined as the man made application of water to guarantee double cropping as well as steady supply of water in areas where rainfall is unreliable (Mutsvangwa et al, 2006).The development of small-scale irrigation is also one of the major intervention to increase agricultural production in the rural parts of a country. This helps farmers to overcome rainfall constraint by providing a sustainable supply of water for cultivation and livestock production (FAO, 2003). Irrigation development is being suggested as a key strategy to improve agricultural productivity and to encourage economic development (Bhattarai et al., 2002). Irrigation in Ethiopia contributes to increase farmers' income, household resilience and buffering livelihoods against shocks and stresses by producing higher value crops for sale at market and to harvest more than once per year. In turn, this provided them to build up their assets, buy more food and non-food household items, educate their children, and reinvest in further increasing their production by buying farm inputs or livestock. However, the benefits are very unevenly distributed among households (Eshetu et al, 2010).

Large-scale irrigation program and other related technologies are quite well known in Ethiopia and the governments of the country actively advanced these schemes. However, many irrigated state farms were abandoned and investment in large-scale and medium scale schemes not developed. At the same time, there was a corresponding expansion of small-scale irrigation program like government canal, private tanks, wells and other streams in order to increase agricultural production. In the same way, in recent years, because of small-scale irrigation systems are financially viable, investment cost recovery operation, maintenance costs, and the ability to replicate investments the program of irrigation in Ethiopia has shifted from large-scale irrigation to small-scale irrigation (Awulachew,et al ,2005). Large scale irrigation schemes comparatively are more profitable and have socioeconomic advantages than small ones (Kadzombe et al, 1973). However, in terms of empowering the local communal people, small scale schemes are suitable as they occupy small land readily available in the rural areas (Chenje et al, 1998).

Since irrigation development has been identified as an important tool to stimulate economic growth and rural development, the regional state of Tigray have led to concentrated efforts to expand irrigation development since 2005 (Hagos et al. 2009). Following the new policy of ADLI, the Tigray regional state including the study area, have introduced small-scale irrigation schemes to achieve food security at household level. For instance in 2007 about 952,000 households have built small water harvesting ponds to promote irrigation at farmer level (MoARD, 2007). A study conducted by Gebremedhin and Pender (2002) in the highlands of Tigray region, showed that irrigation contributed to increase the intensity of input use, especially labor, oxen, improved seeds and fertilizer. Use of compost on irrigated plots was about 50% more likely than on rain-fed plots, controlling other factors. Irrigation contributed to increase crop production by increasing such inputs. The impact of irrigation was 18% increase in crop production relative to rain-fed field plots.

1.2Statement of the problem

Irrigation contributes to agricultural production through increasing crop yields, and enabling farmers to increase cropping intensity and switch to high-value crops (Zhou et al., 2008). In the same way, According to Lipton et al. (2004) cited by Haile (2008) irrigated agriculture can reduce poverty through increasing production and income, and reduction of food prices, that helps very poor households meet the basic needs by improving overall economic welfare, protecting against risks of crop loss due to insufficient rain water supplies, promoting greater use of yield enhancing farm inputs and creation of additional employment, which together enables people to move out of the poverty trap.

The irrigation development, particularly small-scale irrigation is one of the major programs to improve agricultural production in the rural households of a country. It helps poor households to overcome shortage of rainfall by giving optimal water for irrigation agriculture and livestock, strengthen the base for sustainable agriculture, provide increased food security to poor communities through irrigated agriculture and contribute to the improvement of human nutrition (FAO, 2003). According to MoARD(2011), the importance of irrigation development, particularly at smallholders’ level need main concern to raise production and achieve food self-sufficiency and ensure food security at household in particular and national levels at large. Even if Ethiopia has a huge potential in terms of surface and ground water availability and land which are in most cases suitable for irrigation development is in its infant stage and the country is not benefiting from the sub-sector. The major constraints that slow down the development of the sub- sector among others are predominantly primitive nature of the overall existing production system, shortage of agricultural inputs and low level of users' participation in the development and management of irrigated agriculture, limited trained manpower and inadequate extension services. The same finding traditional farm tools, unimproved seeds and fertilizers and poor animal breeds are the major constraints to agricultural development in Ethiopia. The country's ability to support agriculture through development of irrigation has been week (Mengistu, 2000).

The study area is Tigray region, one of the most drought prone regions in the country. Because of that the government of Tigray region is implementing different agricultural development program in order to achieve food security in rural households. Among these programs, irrigation development is primarily taken by the government. Since 2003, small-scale irrigation was used to promote irrigation in 0.5 million food insecure households. In this program, government organizations, international and local NGOs, micro-finance institutions, private sectors and farmers are involved at different levels with different tasks. But such interventions are encountering various social and technical problems that have challenged the strategy and implementation approaches (BoARD, 2006).

Alaje woreda is also one of the woredas in Tigray Region of Ethiopia with an irrigation potential area which is implementing the program with 4548 hectares irrigated land (WBAD, 2012). Hence, the government of Tigray Region gives emphasis on irrigation in this Woreda like the other parts of the region in order to improve the standard living of the society. As a result, because of the availability of ground water as well as river water in some selected Tabias of the Woreda, the government of Tigray and the administrative of the Woreda gave special attention on irrigation in these Tabbies to increase agricultural production of the rural households. However small-scale irrigation policy is a new and recently introduced and lacks in-depth studies on its factors that influence on irrigation participation in policy approaches. This program is not well supported by complete research which is able to examine the impact of small- irrigation on household food security and the determinants of irrigation participation.

A study conducted by Asayehegn et al.(2011), on the effect of small-scale irrigation on the income of farm households in Laelay Maichew,Tigray focus on technical aspects of irrigation schemes and very little is known for the socio-economic factors that have implications on irrigation participation. In the same way Berhane(2009) found that the main factors affects in decision making of any intervention including irrigation that affects their livelihoods were Top-down approaches lack flexibility and do not recognize farmers as the key actors in decision making in Kilte Awlaelo woreda, Tigray regional state, Ethiopia. Most of the previous studies including the above studies on the impact irrigation have been descriptive in nature and have not included any systematic quantitative evaluations. Although these evaluations are relevant measurements of poverty impacts of smallholder irrigation they are not complete, as they do not evaluate direct irrigation impact on household income and food security.

The study area has high water potential; farmers in the areas have long history of traditional practices and by now there is a better irrigation activity that gives opportunity to government in developing modern small-scale irrigation schemes. Irrigation is assumed to improve agricultural production and food security. However, it is not well known to what extent the households using irrigation are better off than those who depend on rainfall in the study area. The knowledge regarding the contribution of irrigation to household income and food security is insufficient in the study area. More importantly, in Woreda Alaje, where this study was conducted, an in-depth comparative analysis studies are scarce on factors that determine rural households' participation in small-scale irrigation and the impact of small-scale irrigation on household food security. Therefore, this study will initiate to choose the study area, and to reveal the seriousness of the problem and to fill the gaps by analyzing the determinant of rural household's participation in small-scale irrigation and the impact of small-scale irrigation on rural household food security.

1.3 Objectives of the study

The general objective of this study is to examine the impact of small-scale irrigation on rural household food security in the study area.

The specific objectives of the study are:

1. To identify the main economic factors that influence farmers to participate in small-scale irrigation and food consumption expenditure.
2. To examine the economic impact of small-scale irrigation on household farm income and food security.
3. To apply the study findings to make recommendation.

1.4 Research questions

This research tries to answer the following three basic and major questions.

1. What are the main factors that determine households' participation in small-scale irrigation and food consumption expenditure?
2. What is the situation of irrigation participants in terms of farm income and food security when compared with their non-irrigation counterparts?

1.5 Hypotheses

The hypotheses of this study are:

1. Participation in small scale irrigation schemes positively and significantly increases the farm income and consumption expenditure of the rural households.
2. Household head sex. education level of the head, access to financial institutions (e.g. Credit), household size per adult, cultivated land, distance to market and FTC and irrigation water availability are statistically significant in influencing the farmers' participation in irrigation schemes.

1.6 Significance of the Study

The achievement of the objectives discussed above is important tool for agricultural development. The study is significant for it increases households' understanding regarding the factors that influence participation in small-scale irrigation and its effect on food security. This is because determining the contribution of small-scale irrigation to household income and their food security status is very important for policy implementation. The study gives a clue for policy makers and planners towards major blockage of farm households' participation in small-scale irrigation and its effect on income in the study area. Generally the significance of the study is that it attempts to provide realistic information on the overall issues of small-scale irrigation development in the study area and for formulating future strategies on smallholder irrigation investment.

1.7 Scope and limitations of the Study

This study was scoped to one administration woreda, two *Tabias* and 150 respondents. The data of the study were based on a cross sectional survey. The objective of this study was to estimate the impact of small-scale irrigation on rural household food security. The study is thus subject to some limitations. For example, many data were highly dependent on the memory of the respondents because of the underdeveloped recording system in the country. Accordingly, some data particular in the quantitative data might be short of accuracies. Some respondents were also unwilling to give the correct response for some sensitive variables. In this case, the study is less confidence to conclude that the data were accurate. Some secondary data at the woreda level are not clear and well documented. However, the study used the different data collection method, random sampling and the respondent consents in order to minimize the limitation, and ensure the reliability of the data and produce valid results.

1.8 Organization of the Thesis

This thesis is organized into five chapters. Chapter one deals the explanation and objective of the study while chapter two deals with the conceptual and theoretical literatures. The third chapter presents the study area. Chapter four presents overall research design of the study. The fifth chapter focuses on the descriptive and econometric results of the study. Finally, chapter six summarizes the conclusion and recommendation.

Chapter Two: Review of Literature

This chapter focuses on review of literature on irrigation and food security. In order to clarify the idea of the study it is important to define the key concepts associated with the empirical studies of the food security and irrigated agriculture. The chapter also reviews different impact assessment methods that are used in investigating the impact of irrigation schemes on household food security.

2.1 Definition and Concept of Food Security

The four determinants for plant growth are water, soil, air and sunshine. Therefore, water is essential to plant-growth and crop-production (Widtose, 2001). Water is important for agriculture, household consumption, industry, hydropower, navigation, fisheries, recreation, and ecosystems. Without water there is no food production. The production of food is needed to guarantee food security. In another way, the availability of water during cropping time is a very important condition for the best production yields (Mollinga, 2000). "Ethiopian agriculture is dominated by cereals, which form the country's staple crop production. Cereals account for about 7o% of agricultural GDP. Over the past decade, cereal production has more than doubled to nearly 15 million tons, mainly as the result of the expansion of cultivation to more marginal lands. Livestock production accounts for about 15 percent of GDP and draught animals are critical for all farming systems (IFAD, 2008)".

Food security is defined in different ways by different organizations around the world. For example in 1996, the definition of food security was agreed and accepted at the World Food Summit in Rome and it was defined food security as a physical and economic access by all people at all times to sufficient, safe and nutritious food to meet their dietary needs and food preference for an active and healthy life (Todaro and Smith, 2011). This definition contains different features, such as food availability, accessibility, utilization and stability. Food availability refers to the existence of food from own production or on the markets. It is a combination of domestic foods production, marketable imports and food aid. It also refers to food supplies available at both the household level and at a national level. However, it is applied most commonly in reference to food supplies at the regional or national level. But food access concerns about having sufficient resources to obtain appropriate foods for a nutritious diet through a combination of home production, stocks, purchase, and gifts, borrowing or food aid. Food access is guaranteed when households and all individuals within them have adequate resources, such as own production, stocks, purchases, gifts, borrowing or aid. Households' wealth is an important determinant for food access when regular livelihood strategies are compromised by poor agro-climatic conditions, high prices, loss of employment, or illness.

Food utilization has a socio-economic and a biological aspect. It refers to nutritional and safety aspects of food security to meet adequate diet, clean water, sanitation and health care to search a state of nutritional well being. It also refers to the household's knowledge of nutrition and childcare techniques. Food Stability complements the previous factors by stressing that food must be available, accessible, affordable and properly utilized on a continuous, long-term basis .It refers to the level of resilience to shocks and other crises. The world had about 800 million food insecure and malnutrition people in 2011 (FAO, 2011). Similarly, Ethiopia had about 3 million (200 thousand in Tigray) food insecure and malnourished people (MoFED, 2012).

2.2 Household food security and measurement

Food security is a broad concept and the meaning and the measurement is not obvious as it may seem. Food security is multidimensional in nature. Accurate measurement and policy targeting, therefore remains a challenge due to many dimensions involved (Hart et al., 2009). According Jacobs (2009, p.411), "A food security target depends heavily on indicators and the measurement of food (in) security. Three categories of food security indicators exist with their respective strengths and limitations: food availability indicators focus on national food supply, yet pay scant attention to individual nutritional status; food expenditure and access indicators measure the monetary value of food as a proxy for food consumption, but often exclude individual nutritional status (or other anthropometric measurements); composite indexes incorporate all the available dimensions of food security into a single index, but the weights attached to components of the index might misrepresent their values in practice.”

Food security can be measured by using supply-side approach or demand-side approach. The food supply approach deals with food availability issues,(e.g food production index, per capita output, food aid delivery, livestock index, crop index and etc.). The food demand equation, on the other hand, deals with accessibility mainly focusing on income, consumption expenditure, nutrition index, and diet diversity score, calorie intake index, hunger index and others (Norton et al., 2010). Depending upon the objective of the studies, some scholars preferred food supply while other scholars preferred the food distribution. Supply approach shows food availability while demand approach indicates food access so that the demand-side approach is the most preferable (G/egziabher, 2008). Hence, the food demand approach was employed to evaluate the impact of small-scale irrigation on rural household food security.

2.3 Definitions and Concepts of Irrigation

Water is a basic need for human beings and animals. It is essential for their metabolic processes. It is used to build healthy Workforce, Ensuring Food Security, Provision of Clean energy for Agriculture, Industry & Service Maintenance of Healthy Ecosystem, Recreation (Aesthetic Value), Transportation, Hedge against climate change and variability catalyst (MOWE, 2013).The most essential use of water in agriculture is for irrigation to produce enough food. Agriculture is the largest user of water in all regions of the world except Europe and North America (FAO, 2002b). About 90% of water withdrawn is taken by irrigation in some developing countries and significant proportions in more economically developed countries WBCSD (2010). But about one fifth of the world (about 1.2 billion people) live in areas of water scarcity, which is not enough water available to meet their daily, needs (World Development Report, 2010).

According FAO(1996a), irrigated agriculture can be defined as the supply of water increased by artificial means, involving the use of water controls technology and including drainage to arrange excess water. Irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. Ethiopia also has a long history of traditional irrigation system (mainly diversion schemes).It enables farmers to increase crop production and achieve higher yields, food availability and affordability for non irrigators and reduces the risk of crop failure if rain fails (Hussein and Hanjra, 2004). India and Far East have grown rice using irrigation nearly for 5000 years (Zewdie et al., 2007). Analysis in Asia indicates that irrigation contributes to increase yields per area, for most crops by between 100%–400%. This has contributed to a reduction in food prices. Irrigation contributes to agricultural productivity through solving the rainfall shortage, motivates farmers to use more of modern inputs and harvest throughout the year and creates employment to members of the households especially to wife and children (FAO, 2011).

According to Fuad (2002) irrigation in Ethiopia can be classified in to three:

1. Small-scale irrigation which are often community based and traditional methods covering less than 200hectares.
2. Medium scale irrigation which is community based or publicly sponsored, covering 200 to 3000 hectares.
3. Large scale irrigation covering more than 3000 hectares, which is typically commercially or publicly sponsored.

2.3.1 Definition and Concept of small-scale irrigation

Small-scale irrigations are type of irrigations that defined as schemes that are controlled and managed by the users. Small-scale schemes developed, operated and maintained by individuals, families, communities, or local rules and landowners, independently of government W. Bart (1996). In the same way, Small-scale irrigation is a type of irrigation defined as irrigation, on small plots, in which farmers have the controlling influence and must be involved in the design process and decisions about boundaries (Tafesse, 2007).

2.3.2 Small-scale Irrigation and Food Security

This study reviewed the economic contribution of small scale irrigation on rural household food security. Irrigation investment in India enabled farmers to increase diversification of crops, and use of more chemical inputs like pesticides, fertilizers or improved seed varieties (Bhattarai et al., 2007) and switched from low-value subsistence production to high-value market-oriented production in China (Huang et al., 2006). Farmers in rural areas suffered from persistent poverty and food insecurity due to climatic changes and dependant on variable rainfall. This leads to low agricultural productivity. As a result, the low productivity areas characterized by persistent rural poverty and increasing population pressure have often resulted in a vicious circle of poverty and environmental degradation (Von Braun, 2008). As many of the low productivity areas did not use water resources, irrigation development is recognized as a backbone of agricultural productivity, enhancing food security, earning higher incomes and increasing crop diversification (Smith, 2004). In many developing countries, small scale irrigation schemes were consider as a means to increase production, reduce the risk of unpredictable rainfall and provide food security and employment to poor farmers (Burrow, 1987).

Small-scale irrigation is a policy priority in Ethiopia for rural poverty alleviation, food security and growth. It enables households to generate more income, increase their resilience, and in some cases transform their livelihoods (MOFED, 2006). Small-scale irrigation in Ethiopia had a significant role in diversification of production to new types of marketable crops like fruits, cash crops and vegetables(Eshetu , 2010).

According to G/egziabher (2008), farm production in irrigation and rainfall-based areas of Tigray has big difference in their productivity. He found that the farm production produced based on irrigation was high due to post harvest storage facilities, and doubling or tripling effects of irrigation while the rain-fed areas produced subsistence crops and encountered a chronic food deficit. A study conducted by Hagos et al. (2009) also indicated that irrigation in Ethiopia increased yields per hectare, income, consumption and food security.

2.3.3 Irrigation Development in Ethiopia

Irrigation is a very ancient agricultural practice which was extensively used by a number of early civilizations such as the ancient Egyptians and Ethiopians Grove (1989) as cited by (Chazovachii, 2012). Evidence also shows irrigation has been practiced in Egypt, China, India and other parts of Asia for a long period of time. Irrigation is the foundation of civilization in many regions. For instance, Egyptians have depended on Nile‟s flooding for irrigation continuously for a long period of time on a large scale (Zewdie et al., 2007).

Irrigated agriculture is not an entirely new phenomenon in Ethiopia. As some literatures indicated, Small-scale traditional irrigation has been practiced for decades throughout the highlands where small farmers could be diverted seasonally for limited dry season cropping (FAO, 1994). According MoWE (2012) modern irrigation has documented in the 1960s where the government designed large irrigation projects in the Awash Valley to produce food crops for domestic consumption and industrial crops for exports and it was strongly believed that rain fed agriculture should be supplemented by irrigation in order to achieve national food self-sufficiency and ensure household food security. The total irrigation potential in Ethiopia is 3,798,782 hectare but currently irrigation schemes have covered only 368,160 hectare, 10% of the potential(MoFED, 2012).

According MoWE (2012), Tigray region has 300,000 hectares irrigation potential which is 4% of its surface are. The region has been used only 2% of its irrigation potential. Accordingly, it has vast unused potential of irrigation resources. According (Awulachew et al. 2007), the reasons for the poor development of irrigation in the region (country) are fragmented and small farmland, political instability, lack of technologies, government - owned land policy, lack of financial resources, and weak institutional set up in the region (country).

2.3.4 An Overview of Ethiopia's Food Security Situation and Irrigation

According Seleshi et al, (2005), agricultural production in Ethiopia has affected by increasing population, deforestation and land distribution. This reflected in a decrease in household production, grazing land. Hence, it has become a common phenomenon to ask for emergency food assistance for acutely food insecure people in Ethiopia.

According WFP (2010), in Ethiopia, due to the situations of people who do not have the capacity to produce or buy enough to meet their annual food needs even under normal weather and market conditions a total of 5.23 million people would need emergency food assistance from January to June 2010. The Productive Safety Net Program (PSNP) reach to support over 7.23 million people in 300 Woredas for seven regions (Tigray, Amhara, Oromiya, SNNPR, Afar, Harar and Dire Dawa) who are facing chronic food insecurity situation starting 2006. Hence, the expansion of small-scale irrigation schemes was taken as the main development strategy in order to reduce crop failure due to drought and erratic rain fall conditions in Ethiopia by preparing a National Medium-Term Investment Program (NMTIP) for Water Sector Development Program (WSDP) for 15 years (2002-2016) ..

In Tigray region, farmers produce insufficient amount because of inconsistent rain fall, and then the government of the region has given great attention to small-scale irrigation as a means to ensure food security and poverty reduction (Awulachew, 2007).The adoption of new technology (e.g. irrigation) is the major powerful for agricultural growth and poverty reduction (Norton et al., 2010).This indicates that investment in irrigation can increase farmer's independence on rainfall, it increases irrigated farmland, it generates employment, it promotes farmers to produce two or three times in a year and use more of chemical inputs. Small scale irrigation in developing countries was considered as a means of increasing production, reducing the dependence on rainfall and provides jobs to the poor (Chazovachii, 2012). Small scale irrigation increases land productivity, crop yields, adoption of mineral fertilizers and enables to diversify into non-conventional and market-oriented products (Eshetu, 2010). It improves farm households' diet, incomes, health and food security (Torell and Ward, 2010). Hence irrigated agriculture is accepted as essential in increasing land productivity, enhancing food security, earning higher and more stable incomes and increasing for multiple cropping and crop diversification (Smith, 2004).

2.4 Empirical Studies in Irrigation and Food Security

2.4.1 Determinants of Household irrigation participation Food Security

Different studies were conducted to identify determinants of irrigation participation and food security in different countries including Ethiopia. For example, a study conducted by Dillon (2011) found that household head education level, gender of the head, age of household head, landholding, livestock units, access to credit from financial institutions, farmland size, distance to the roads, distance to markets, distance to rivers, household sizes, access to market information, type of peasant associations and training are important factors influenced to participate in irrigation farming. Similar studies found that rural associations, information access are vital instruments to bring attitudinal change and motivate respondents to adopt new technologies through informal education, panel discussion, public meetings and other demonstrations (Nugusse, 2013). According Asayehegn et al. (2011), farmers who are members of the formal and informal institutions (water user association, peasant associations and local leadership), education are factors influenced to participate in irrigation farming. A study conducted by Mati (2008) also found that the investment cost is the most determinant factor for irrigated farming decision (Mati, 2008).

According to Epherm (2008) household food security in the north eastern part of Ethiopia were strongly associated with various socio-economic and bio-physical factors that influence the food security status of households were age of household head, dependency ratio, size of cultivated land, total number of livestock owned, manure application, land quality and farmer's knowledge on the effect of land degradation on food security. Similar study by Shiferaw et al (2004) found that the analysis of household food security determinants in Southern Ethiopia that adoption of improved technology; having larger farm size and having better land quality were found an important role in ensuring household food security in the study area.

2.5 Irrigation techniques/ methods

Irrigation methods are the system how to obtain water for irrigation purposes from its sources is. It depends on water resources, water rules, rain water, topography, plants cultivated and growing seasons Dupriez and De Leener (2002). There are only two general methods of applying irrigation water.1 surface irrigation 2. Sub-surface irrigation

2.5.1 Surface irrigation

Surface irrigations are the oldest methods of irrigation, which convey water from the survey to the fields in lined or unlined channels. Surface irrigation is the introduction and distribution of water in a field by the gravity flow of water over the soil surface. The primary methods of applying water are Basins irrigation, Boarders irrigation, Flood irrigation and Furrows irrigation Widtose(2001). One can choose these irrigation methods depending on the nature of the soil, the form of the land, the head of the water stream, the quantity of water available and the nature of the crop.

2.5.1.1 Basin irrigation

Basin irrigation is the most common form of surface irrigation, particularly in regions with layouts of small fields. A basin is a piece of land, small or large, surrounded by earth bunds in which water is pounded. The field to be irrigated is divided in two units surrounded by levels or dams. Gated outlets, siphon tubes, spiels, and hydrants conduct water from delivery channels in to each basin. This type of irrigation is suitable for all types of soil and efficient use of water but it needs high initial cost for leveling land.

2.5.1.2 Furrow irrigation

- Furrow irrigation is accomplished by running water in small channels that are constructed with or across the slope of a field. Furrow irrigation avoids flooding the entire field surface by channeling the flow along the primary direction of the field using 'furrows,' 'creases,' or 'corrugations. Water infiltrates through the wetted perimeter and spreads vertically and horizontally to refill the soil reservoir. Water is diverted in to furrows from open ditches or pipes. Theadvantage of this type of irrigation are Uniform application of water, less evaporation loses, less intercultural operations but it needs high cost for preparing furrows. Because it requires more and require more labor

2.5.1.3 Border irrigation

Border irrigation is an open-field method viewed as an extension of basin irrigation to sloping, long rectangular or contoured field shapes, with free draining conditions at the lower end. Here a field is divided into sloping borders**.** Water is applied to individual borders from small hand-dug checks from the field head ditch. Soils can be efficiently irrigated which have moderately low to moderately high intake rates but, as with basins, should not form dense crusts unless provisions are made to furrow or construct raised borders for the crops. The benefits of this type of irrigation are uniform application of water, uniform application of water, efficient use of water but it requires repairing of ridges and supervision during irrigation and land needs to be graded uniformly

2.5.1.4 Flood irrigation

Flood irrigation is an ancient method of irrigating crops. It was likely the first form of irrigation used by humans as they began cultivating crops and is still one of the most commonly used methods of irrigation used today. Water is delivered to the field by ditch, pipe, or some other means and simply flows over the ground through the crop. This type of irrigation is least cost method and does not require any skill but it is inefficient method, result in uniform stand of crops and low yield, and more wastage water due to run off, deep seepage and evaporation.

2.5 .1.5 Drip irrigation

This method is one of the more advanced techniques being used today because, for certain crops, it is much more efficient than flood irrigation, where a larger portion of the water is lost to evaporation. Drip irrigation is practiced in dry, arid regions where water is scarce and must be used sparingly. Water is run through pipes (with holes in them) either buried or lying slightly above the ground next to the crops. Water slowly drips onto the crop roots and stems. The advantage of this type of irrigation are very economic, surface evaporation is reduced, sweated to arid regions and can be used for applying fertilizers, increases yield by 50-60%. But it needs high initial cost and maintenance.

2.5.2 Sprinkler irrigation

In this method of irrigation, water is sprayed into the air and allowed to fall on the ground surface somewhat resembling rainfall. According to Dupriez and De Leener (2002), Sprinkler irrigation imitates rainfall. It is also called overhead irrigation. The spray is developed by the flow of water under pressure through small orifices or nozzles. The pressure is usually obtained by pumping. In contrast to surface irrigation, sprinkler systems are designed to deliver water to the field without depending on the soil surface for water conveyance or distribution. This type of irrigation is beneficial for uniform distribution of water and highly efficient use of water, water application at controlled rate and used for cooling crops during high temperatures and frost control during freezing temperatures. But it needs high initial costs and more maintenance, and there is high evaporation lose

Chapter Three: Materials and Methods

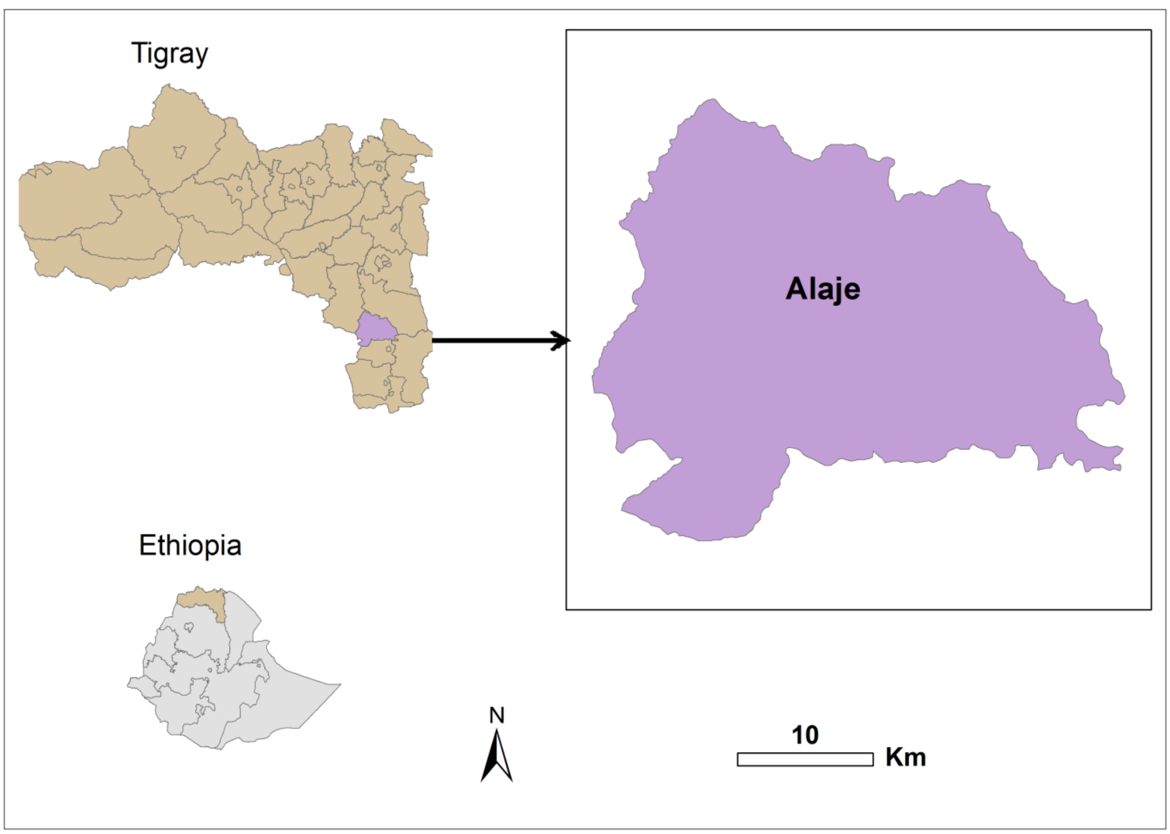
This chapter explains the research strategy that guided the study and the different methods used for data collection and analysis. Furthermore, it discusses the strengths and limitations of these methods based on practical experiences of the research work.

3.1 Description of the study area

3.1.1 Location

This study once is Alaje Worda located in the Southern Zone of Tigray region. It is about 85Km far from the capital city of Tigray Regional State, Mekelle. It has 20 rural and 1urban Tabias. It is a part of the Debubawi Zone and bordered on the south by Endamehoni, on the southwest by the Amhara Region, on the north by Debub Misraqawi Zone, and on the southeast by Raya Azebo. The administrative center of this woreda is Adi Shehu.

Figure 3.1 Map of Alaje Woreda.



3.1.2 Selection of the study area

The study was in two Tabias of Emba alaje woreda:- Atsela and Ayba. The Tabias have relatively high water potential, farmers in the areas have long history of traditional practices, the Tabias have better irrigation activities that give opportunity to government in developing modern small-scale irrigation schemes and the Tabias accessible in terms of roads, market etc. Therefore because of the above reasons, the researcher chose the woreda as well as the Tabias to study the impact of small-scale irrigation on rural household food security.

3.1.3 Agro-ecological Condition

The study area has three agro-climatic zones such as Highland (dega), Mid Highland (woina dega) and Low land (kola) dominated by Highland (dega). The annual temperature ranges between30°c and45°c with an average of 37.5°c. The main rainy season extends from late June to early September. The distribution of the rainfall is, however, with large variability, untimely and irregular in nature. The elevation significantly affects the climatic condition, vegetation coverage, resource distribution, human settlement and agricultural practice.

3.1.4 Socioeconomic Condition, and Physical and Natural Resources

The woreda contains a total population of 107,972 of whom 52,844 are men and 55,128 are women and 7,568 are urban population. The Woreda contains total 24,784 households and total cultivate land 22457 hectares. For the land under cultivation in this Woreda, 65.39% was planted in cereals, 24.94% in pulses, and 51 hectares in oilseeds; the area planted in vegetables is missing. The area planted in fruit trees was 57 hectares, while 32 were planted in Gesho. 65.36% of the farmers both raised crops and livestock, while 33.63% only grew crops and 1.0% only raised livestock. Land tenure in this Woreda is distributed amongst 86.43% owning their land, and 10.73% renting; the number held in other forms of tenure is missing The total households of the woreda are 24,784 and the majority of the population practiced Ethiopian Orthodox Christianity. The two largest ethnic groups in this Woreda are the Tigrayan(98.18%), and the Agaw Kamyr (1.4%) and other ethnic groups made up 0.42% of the population. Tigrinya is spoken as a first language by 98.78%, and Kamyr by 0.96% of the population; the remaining 0.26% spoke all other primary. About education, 10.46% of the population were considered as literate, 13.46% of children aged 7-12 were in primary school; 0.96% of the children aged 13-14were in junior secondary school; 0.55% of the inhabitants aged 15-18 were in senior secondary school. Concerning sanitary conditions, about 23% of the urban houses and 13% of all houses had access to safe drinking water at the time of the census; about 14% of the urban and 4% of the total had toilet facilities CSA (2007).

3.2 Types of Small-scale irrigation in the study area

3.2.1 Concrete canal river diversion

River diversion irrigation systems are practiced in the two Tabias. Atsela River is the main source of water for the modern irrigation system in Atsela Tabia.

Figure3.2 Modern river diversion and output in 2013/2014(Photograph by the author 2014)

The river is diverted by cement concrete canal for irrigation purposes. The canal river diversion water is used for irrigation.

3.2.2 Traditional river diversion

Traditional river diversion is the dominant method used by farmers in both Tabias. This irrigation system is simple for farmers to practice by inheriting the knowledge from grandparents but the amount of water and seasonality of rivers are major problems. Many farmers use traditional irrigation to complement other irrigation systems like modern river diversion and motor pump irrigations.

Figure 3.3 Traditional river diversions (Photograph by the author, 2014)

3.2.3 Hand pump

This is a type small-scale irrigation with pumping arrangement for lifting water mainly from surface sources where diversion by gravity may not be feasible. As operation and maintenance of these schemes is costly, they are successful mainly in areas with good market access, better service delivery and growing of high value crops. Based on the size of the pump they can be privately owned or communal.

Fig 3.4 Hand pump (Photograph by the author, 2014)

3.2.4 Motorized pump

Motorized pumps are widely used irrigation systems in the study area. Most of the farmers bought them as part of a group. Other households gain access to the pumps through renting from the owners.

Figure 3.5 Motorized pump (Photograph by the author, 2014)

3.3 Research methods

3.3.1 Sources and Methods of data collection

The study area has a total of 24,784 households living in different villages. Considering time and cost constraints a questionnaire survey found to be applicable method. This study was based on both primary and secondary data collected from households in Alaje woreda. To obtain primary data, structured questionnaire with both open-ended and closed ended questions were used to collect demographic information of household heads, like age, sex, educational level, household size in adult equivalent, cultivated land, farm experience, access to extension service, access to credit, irrigation access, livestock holding, market access, household income and expenditure of the household heads. However; secondary data were also collected from the Plan and Finance of Woreda Emba Alaje(WOFED, 2011), Office of Agricultural and Rural development Woreda Emba Alaje(WBAD, 2011) and Office of Water and Mineral Energy of Woreda Emba Alaje(WWME, 2011). The information is used to evaluate the existing works and compare this study with the previous studies.

Data collection from households were carried out by two enumerators (12 grades complete) and the researcher by applying face to face interview. The selection of enumerators was done depending on the knowledge of the study area, their local language, the educational level and personal willingness to take part in the survey. After the selection process completed, one day orientation and discussion about the objectives of the survey, discussions on each questions was also undertaken. This helped in creating a common understanding by avoiding misconception and increasing clarity. Finally, a pre-test survey was conducted with three volunteer farmers. A support letter written by the Woreda administration to each Tabia center was handed over to the enumerators. This helped to complete the survey smoothly. Finally, the collected data completed, coded, and entered for further analysis using STATA statistics software. Descriptive statistics and econometric model were used to analyze the data.

3.3.2 Sampling techniques

This study was used a three-stage sampling technique to select sample respondents. Firstly, Alaje Woreda is purposely selected mainly because of the area is relatively better small-scale irrigation activities that gives opportunity to develop modern small-scale irrigation schemes. As a result, the researcher initiated to select the woreda for this study. Then finally, out of total 21 Tabias found within the woreda two Tabias; namely Ayba and Atsela were purposely selected mainly because of availability of irrigation schemes. Secondly, the sampling frame obtained from the Tabias office was stratified into two groups of irrigation participants and non-participants. For this study, participants are those households, in the two Tabias, who used irrigation (River diversion or well).While the non-participants are those households, in the same Tabias, with no irrigation access from the scheme. Finally, 150 farm households consisting of 60 irrigation users and 90 non –users were selected from the identified list using simple random sampling technique taking into account). Time and financial constraints are among the factors that forced the researcher to limit the number households covered in the study.

3.3.3 Methods of data analysis

To achieve the objectives, this study was used both descriptive statistics (mean, mean difference, percentage, standard error and standard deviation) and Heckman's two stage estimation (Binary Probit model at the first stage and OLS model at the second stage) were used to analyze the collected data. The Foster Greer Thorbecke (FGT) poverty indices were also used to give a summary of the incidence, depth and severity of poverty in the study area. The statistical significance of the variables in the descriptive part was tested for both dummy and continuous variables using chi-square and t-test, respectively.

In this study, to estimate the impact of small-scale irrigation on rural household food security, an assessment of selected socioeconomic characteristics, demographic characteristics and institutional factors such as age, sex, family size in adult equivalent, education level, cultivated land size, soil fertility, farm experience, access to credit, access to extension service, water irrigation availability, distance to market to, distance to farmers training center and total livestock holding of the sample household heads are very important. Households that are irrigation users and non-users were used as the concern groups and annual food expenditure per adult equivalent was used to examine the impact of small-scale irrigation on rural household food security status.

Definition of Variables and Working Hypotheses

Different variables are expected to affect rural households' decision participation in small-scale irrigation schemes and level of income from small scale irrigation in the study area. The variables hypothesized to influence participation decision in small-scale irrigation and food security status are explained in this section.

Dependent Variables

For the heckman second step analysis household expenditure in adult equivalent is a continuous variable measured in ETB. The dependent variable of the first stage of this study is participation in the small-scale irrigation scheme with dummy values of 1 for households having access to irrigation and 0 for those having no access to the irrigation scheme in the study area. Moreover; the outcome variable for this study is food consumption expenditure per adult equivalent. The dependent variable was assumed to be influenced by its independent variables. Each variable is defined with their hypothesis based on economic theory and results of previous empirical studies.

Independent variables

The independent variables that are hypothesize to influence the households' decision to participate in small scale irrigation and food security status are combined effects of various factors such as: demographic, socio-economic and institutional factors. Based on review of literatures on factors influencing participation in small scale irrigation and level of farm income the following potential explanatory variables are considered in this study and examined for their effect in farmers' participation decision of small-scale irrigation and food security status. These are presented as follows:

Demographic and Socio-Economic Variables

Sex of the household head (hhsex): This is a dummy variable with values1for male and 0 otherwise. Male household heads are expected to have higher income compared to female household heads because of better labor inputs used and with regard to farming experience. Male headed farmers are also better than the female headed farmers since it is assumed that male household heads have more exposure and access to information and new interventions than female household heads, which might enable them to participate in the small scale irrigation as early as possible and their income is higher than their counterpart. According to Bradshaw (2006) gender is an important determinant in technology adoption. Men often control household finances and decisions regarding purchases of agriculture technology and inputs (Knowler and Bradshaw 2006). Hence this study was hypothesized male headed households were more likely to participate in the small-scale irrigation scheme in the study area.

Age of a household head (hhage): Age is a continuous variable measured in years. It is one of the factors that determine decision making of a person. Previous studies found a two way relationship between age and decision to participate in irrigation scheme and other agricultural technologies. Younger farmers are more innovative and open to technological advances and be more willing to adopt a new technology (Diederen et al. 2003). Therefore, this study hypothesized negative relationship between age of the household head and participation in irrigation scheme. At younger ages the probability of participating in small-scale irrigation increases.

Education level of a household head (hheduc): This is a continuous variable measured in formal schooling years completed by the household head. That is the number of years of schooling attained by the sampled households' heads up to the time of the survey. Previous studies indicated that the possibility to adopt new methods of farming increased along with education level. That is educated farmers would more readily to adopt irrigation technology, may be easier to train through extension support and have a positive impact on irrigation participation. On the other hand, as the educational level of farmers is increased, their interest to work in non-agricultural activities may be increased that leads to the declining of the willingness to participate in contract farming program. According Feder et al. (1985) farmers with more education have been shown to adopt modern agricultural technologies sooner. Therefore, the variable was hypothesized to influence the participation decision on contract farming and gross margin earnings of the farmers in both negative and/or positive directions.

Farming experience (farmexp): This is a continuous variable refers to the total number of years that the sampled household has spent in farming. A farmer with longer experience in farming, a wider knowledge and experiences are gained on the operation and conduct of the agricultural activities and methods of production. Thus, this variable was hypothesized to have a positive relationship with participation in the small-scale irrigation scheme. That is more likely that farmers with longer farming experience are ready to accept changes and adopt new ideas and techniques.

Family size (hhsizepa): This is continuous variable measured in total number of the household members living under the same roof adjusted to adult equivalent. Family size in adult equivalent of a household is calculated by using the conversion factor and multiplying each household member with respective conversion factor and then summing (Annex 2). Previous studies found a two way relationship between family size and decision to participate in irrigation scheme and other agricultural technologies. Therefore, this variable was hypothesized positive effect household heads decision to small-scale irrigation participation. A household with large labor force can participate in small-scale irrigation more than a household with small- number of labor force (Shimelis, 2009).

Cultivated land holding (cultland): This is a continuous variable measured in Tsimad and it refers to the total cultivated land size of the household heads. In many previous studies, it has been noted that enough size of land holding is the basic requirement for adoption of agricultural technologies. It is thus hypothesized that the larger the farm size the farmer has, the higher the probability to adopt small-scale irrigation technology. Total cultivated land should have a positive relationship with income of a household (Kamara et al. 2001).

Soil fertility(soilfertiity): this is a dummy variable taking value 1 if the soil is fertile and 0 is infertile. It is one of the factors affecting crop production. Fertility of land has direct relationship with productivity. The analysis between soil fertility and state of food security indicates that they are systematically associated. The quality of land can also influence the decision whether or not to adopt an agricultural technology(Zhou 2008) Hence, it is hypothesized that farmers who have soil fertile are more likely to be food secure than those who don't have the same.

Total Livestock Holdings (tlu): This is a continuous variable refers to the total number of herd in TLU. A household livestock size in TLU is calculated by multiplying the number of each type of animal by their conversion factors and then summing. Livestock is important source of income, food and draught power for crop cultivation in Ethiopian agriculture. More livestock holding is expected to increase the probability of participation in small scale irrigation. Livestock may also serve as an alternative for oxen ownership, which is important for farm activity. Therefore, in this study it is hypothesized that higher TLU will have positive relationship with household heads decision to participate in small -scale irrigation and food security status. The owner of more oxen lead to an ability of ploughing more land on time, thereby achieving crop yields and earning higher income leading to food secure.

Distance to market (dismkt): This is a continuous variable measured in kilometer. It refers to the distance between the households' home and the nearest market. This shows access to the market to buy input and to sell output. As the farmer is nearer to a market, the higher will be the chance of participating in small-scale irrigation and selling farm income. Characteristics of different localities can affect the adoption decisions (Knowler and Bradshaw 2006). It is, therefore, expected that households nearer to market center have better chance to participate in small-scale irrigation and improve household food security status.

Distance farmers training center (disftc): This is a continuous variable measured in kilometer. Moll (2004) argued that information is a source of knowledge, awareness and change. The necessary information can be gained from training, demonstration or workshop, and through mobile, TV and radio. The farmer training center is a source of information for the tabia resident. There are development agents in the tabias who teach the local communities about the application of the new technologies. The longer the distance from home to the farmer training centers and/or development agent offices, the lower is the probability to start and use irrigation.

Institutional Factors

Access to extension service (accexten): This is a dummy variable with values of 1 if the household head has access to extension service and 0 otherwise. This indicates that whether the household head gets extension service from development agents (DAs) or not. Extension service provides the necessary information to acquire new skills and knowledge to farmers to improve agricultural production. Bacha et al.(2011) found significant difference between irrigators and non-irrigators in access to extension. The higher is the probability for the farmers to access and use irrigated agriculture. It is, therefore, this variable was hypothesized to positively influence participation in the small-scale irrigation scheme.

Access to credit (credit): is a dummy variable that takes the value 1 when the household takes loan and 0 otherwise. Access to credit is an important source of investment. Those households who have access to credit have a better possibility of getting farm inputs(Norton et al.1970).Therefore, it is hypothesized that access to credit determines farmers' decision to participate in small scale irrigation and food security status positively. This more implies that the formal and informal credit facilities that advantage for rural farmers are a very important asset in rural livelihoods to finance agricultural inputs activities.

Table3.1. Summary of independent variables and hypothesized signs

Variable codes	Variable description	Hypothesized sign
Hhsedx	Household head's sex (1=male, 0=female)	(+)
Hhage	Household head's age (years)	(-)
Hheduc	Household head's education level (years of schooling)	(+)
Hhsizepa	Household size (number of members in adult equivalent)	(+)
Cultland	Cultivated land size(tsikmad)	(+)
Soilfertility	Farmer's perception soil fertility status(=fertile,0=infertile)	(+)
Farmexp	Farming experience(years)	(-)
Accexten	Extension service access(1= yes,0= no	(+)
Credit	Credit access (1=yes, 0= no)	(+)
Tlu	Livestock holding (tlu)	(+)
Dismkt	Distance to market for buying inputs(kilometers)	(-)
Disftc	Distance from home to farming training center(km)	(-)
Wateravi	Availability of irrigation water (1=yes,0=No)	(+)

Source: Compute own survey, 2014

3.4 The FGT, Grere and ThorbeckeFGT) poverty indices

The Foster, Greer and Thorbecke (FGT) poverty measures were calculated to examine the incidence, depth and severity of poverty among irrigators and non-irrigators as follows:

$$P_\alpha = \frac{1}{n}\sum_{i=1}^{q}\left[\frac{(z-Y_i)}{z}\right]^{\alpha} \qquad (1)$$

Where:

P_a = the FGT poverty index

n i= the number of sample households

Y_i. =is consumption expenditure per adult equivalent of the i^{th} household

z =represents the cut-off poverty line

q = the number of households below the poverty line

α =is the poverty parameter which takes a value of 0, 1, or 2.

The poverty parameter is a non-negative parameter indicating the degree of sensitivity of the poverty measure to inequality among the poor. The incidence of poverty (head-count index), estimated when $\alpha = 0$, measures the share of the population below the poverty line. The poverty depth index estimated when $\alpha = 1$, captures information regarding how far households are from the poverty line. The poverty severity index estimated when $\alpha = 2$, takes into account not only the distance separating the poor from the poverty line but also the inequality among the poor.

The larger value of α gives emphasis to the poorest of the poor indicating greater sensitivity of the poverty measure to inequality among the poor (Foster et al., 1984).The FGT poverty measures were calculated using Distributive Analysis Stata Package (DASP) based on the minimum per capita adult-equivalent caloric intake which was taken as 2200 kcal per adult equivalent per day. The nutritional requirements often used are the international standards set by the World Health Organization (WHO) and the Food and Agricultural Organization (FAO). This cut-off value is estimated to be Birr 1985 per adult equivalent per annum for 2010/2011.

3.5 Model of specification

Determining the impact of small- scale irrigation on rural household food security is one of the objectives of this study. Therefore, participation to irrigation is the dependent variable which is determined by the independent variables such as household characteristics, asset holdings and access to services. In this study, participation to small-scale irrigation status is a dichotomous variable (1= irrigation participant and 0 = non-participant).

Since the dependent variable is taking a value of 0 or 1, representing irrigation participant or non-participant status which is unobserved and the resulting model is non linear, it cannot be estimated using OLS. Hence, Probit model guarantee that the estimated probabilities lie in the range 0 to 1(Pindyck and Rubinfeld, 1981). So in this study probit model method was employed. Depending on Gujarati (1995) and Aldrich and Nelson (1984), Hosmer and Lemeshow (1989) the functional form of probit model is specified as follows;

$$\Pi(x) = E(y=1|x) = [\ 1/\ (1+e^{-(\beta o+\beta i x i)})\ ] \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

For simplicity, we write (1) as

$$\Pi(x) = 1/\ (1+e^{-Zi}\ ) \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where $\pi(x)$ =is a probability of being irrigation users ranges from greater or equal to 0 nd less or equal to 1.

Z_i = is a function of n-explanatory variables (x) which is also expressed as

$$Z_i = \beta o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n .$$

Bo = intercept

B_1, β_2 . . . β_n = slopes (coefficients) of the equation in the model.

The probability that a given irrigation users is expressed by (2) above while, similarly, the probability for non-users as;

$$1-\pi(x) = 1/(1+e^{zi}) \quad \ldots\ldots (3)$$

Therefore we can write this as;

$$\Pi(x)/[1-\pi(x)] = (1+e^{Zi}/1+e^{-Zi}) = \boldsymbol{e^{Zi}} \quad \ldots\ldots (4)$$

Now $\pi(x)/[1-\pi(x)]$ is simply the odd ratio in favor of irrigation users. The ratio of the probability that a household is irrigation user to the probability of that it is be non-user.

$$L_i = \ln[\pi(x)/[1-\pi(x)] = Z_i \quad \ldots\ldots (5)$$

Where $Z_i = \beta o + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_n X_n$. If the disturbance term (Ui) existed, the logit model becomes,

$$Z_i = \beta_O + \beta_1 X_1 + \beta_2 X_2 = \ldots + \beta_n X_n + U_i \ldots\ldots (6)$$

L_i = log of the odd ratio, which is not only linear in X_i but also linear in the parameters.

X_i = vector of relevant explanatory variables.

In this study two groups of households are compared to analyze the impact of the small-scale irrigation scheme on rural household food security. These groups called the treatment group and the control group.

3.5.1 Impact Analysis

Heckman two-stage Procedure

According Zaman(2001), evaluating the impact of a program on an outcome variable using regression analysis can lead to biased estimate if the underlying process which governs selection into a program is not incorporated in the empirical framework. This is because the effect of the program may be over (under) estimated if program participants are more (less) able due to certain unobservable characteristics, to derive these benefits compared to eligible non-participants. That is if household food expenditure of the irrigation participants is significantly higher than that of non participants, we can not necessarily point this difference to the influence of the small-scale irrigation program because of the self selectivity component that should be taken care. Therefore, to evaluate the impact of a program, a model employed can be expressed as:

$$Y = \beta X + \alpha D + u \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (1)$$

Where Y is the outcome/impact, X is a vector of personal exogenous characteristics and D is a dummy variable (D=1, if the individual participates in the program and 0 otherwise). From this model, the effect of the program is measured by the estimate of α. However, the dummy variable "D" cannot be treated as exogenous if the likelihood of an individual to participate or not to participate in the program is based on an unobserved selection process (Maddala, 1983).

Heckman two-step procedures are considered as an appropriate tool to test and control for sample selection biases (Wooldrige, 2002). It involves two equations. The first equation (i.e., the participation equation) attempts to capture the factors governing participation in a program. This equation is used to find a selectivity term known as the 'Mills ratio' which is included as independent variable to the second equation known as outcome equation. If the coefficient of the 'selectivity' term is significant then the participation equation is governed by an unobserved selectivity bias is confirmed. Furthermore, with the addition of extra term, the coefficient in the second stage 'selectivity corrected' equation is unbiased (Zaman, 2001).

Therefore, to evaluate the impact of small scale irrigation on household food security, the Heckman two-step procedure is employed.

Let Z be be a group of K variables which represent the characteristics of a household i which influences the probability of participation in irrigation agriculture measured by a latent variable Di and γ_k are the coefficients which reflect the effect of these variables on the probability of being an irrigation farmer, and is X is a group of variables which represent the characteristics of household i which determine household's food security (C_i) and β_s are the coefficients which reflect the effect of these variables on household food security. Thus, the Heckman two-step procedure takes the following form:

$$D^*_I = \sum Z_i \gamma_{k} + u_{i\ (k=1up} \text{ to } k) \ldots\ldots (2)$$

$$Ci=\sum\beta_s+X_{is}+\varepsilon_{i(s=1 \text{ up to } s)} \text{ Observed only if } D_i >0 \ldots\ldots (3)$$

Where the disturbances u_i and ε_i follow a bivariate normal distribution with a zero mean, variance σ_u and σ_ε respectively, and covariance $\sigma_{\varepsilon u}$. Therefore, we define a dichotomous variable D_i which takes a value 1when a household is an irrigator and 0 otherwise. The estimator is based on the conditional expectation of the observed variable, household food security (Ci):

$$E\ (C_i\ /D_i>0) = x\beta+ \sigma_{\varepsilon u} + \sigma_\varepsilon\lambda\ (-\gamma_k) \ldots\ldots (4).$$

Where λ is the inverse Mills ratio defined as $[\lambda(-\gamma z)= \phi(- \gamma z)]/[1- \varphi(-\gamma z)]$; β and γ are he vectors of parameters which measure the effect of variables X and Z, ϕ and φ are the functions of density and distribution of a normal, respectively. The expression of conditional expectation shows that C_i equals β x only when the errors u_i and ε_i are none correlated, i.e., $\sigma_{\varepsilon u}=0$; otherwise, the expectation of C_i is affected by the variable of equation 2. Thus, from expression 4 we find that:

$$C_i/D_i>0 = E(C_i/D^*>0) +V_i = x\beta+ \sigma_{\varepsilon u}\sigma_\varepsilon\lambda(-\gamma z)+V_i \ldots\ldots (5)$$

Where V_i is the distributed error term, $N\ [0,\sigma_\varepsilon(1-\sigma_{\varepsilon u}(\lambda(\lambda- \gamma z)))]$

Chapter Four: Result and discussion

In this chapter the measurement procedure of the impact of small-scale irrigation on food security status of the household and findings from descriptive and econometric analyses are presented and discussed. The variables included in the model are defined in each of the following tables. The dependent variable for the first stage of the Heckman two-step is participation in small-scale irrigation. This variable is a dummy variable (1= yes, 0=no) and for the second stage of the model household food security status is a continuous variable measured by the annual food expenditure per adult equivalent. Before discussing the econometric results, some descriptive statistics are presented.

4.1 Descriptive Analysis

The descriptive analyses tools used are mean, percentage mean, mean difference and standard deviation. The descriptive statistics was run to observe the distribution of the independent variables. The socio-economic and institutional characteristics of the respondents such as age, sex, level of education, farm experience, household size in adult equivalent, cultivated land holding, soil fertility, livestock holding, access to extension service, access to credit, distance to market, distance to farmer training center, and uses of household heads are analyzed. Of the total sample respondents 60 were participants and 90 were non-adopters. These were 40 and 60 percents of the total sample, respectively. T-statistics and chi-square (χ 2) tests were used whether they are statistically significant or not using t-statistics and chi-square (χ 2) tests. The t-test is used to test the significance of the mean value of continuous variables of the two groups of users and non-users and chi-square (χ 2) is used to test the significance of the mean value of the potential discrete (dummy) explanatory variables.

Table 4.1 Summery of descriptive statistics result of the dummy variables by access to irrigation

Variables	Participants	Non participants	P-value
	Percent	Percent	
Hhsex			
Male=1	78.3	81.1	0.677
Femae=0	21.7	18.9	
Accexten	98.3	38.9	0.000***
Credit	58.3	5.6	0.000***
Soilfertility			
Fertile=1	56.7	38.9	0.032**
Infertile=0	43.3	61.1	
Wateravi			
Yes=1	95	30	0.000***
No=0	5	70	

Source: Compute own survey, 2014

According to the result shown in table (4.1), sex of the household head is insignificant variable. Out of the total sampled households, 80% (120 households) were male-headed and 20% (30 households) were female-headed. The chi-square value shows that the proportion male headed households are relatively higher for irrigation participants (78.3%) than for the non participants (21.7%). But it is statistically insignificant. The male headed and female headed households equally likely to adopt small-scale irrigation in the study area. This might because they have equal access to irrigation. The percentage difference on land quality was statistically tested and it was found to be significant at 5% level of significance. This revealed that there was systematic association between land quality and small-scale irrigation participation. It shows that higher quality of land could increase participation in small-scale irrigation. This indicates that as land quality becomes fertile, household heads become eager to accept irrigation technology (keeping other variables constant).

The extension service is delivered to farmers mainly via Development Agents (DAs) through sharing of modern agricultural knowledge and information to improve farmers' lives in a better way. DAs are leading workers in day-to-day contact with farmers. Thus, they give technical advices to farmers by organizing trainings at Farmers Training Center (FTC) and visit to farmers' fields. The adoption of new technology, among others, was Extension contact availability of input supply, and access to credit is the important institutional services that were required to increase agricultural productivity. It was understood from previous studies that an increase in productivity is achieved through farmers' access to appropriate extension services. It is learnt that sample households in the study area do have a better access to extension services that was illustrated by frequent visit of extension agents, participation in demonstration day, training of the farmers and above all initiatives of the farmers to knock the doors of the extension agents. According Madhusuda B. et al. (2002), agricultural extension services play a pivotal role in the motivation of farmers towards the adoption of improved irrigation practices. The introduction of high valued crops, efficient use of water and proper use of inputs have all been deemed as significant factors for crop production and productivity. Hence, the result of this study is consistent with that study which revealed that 98.3% of the participants and 38.9% non participants get extension service. The chi square test indicated that there is significant relationship between irrigation users and non users with regard to extension service at 1% level of significance. Credit is an important institutional service to finance poor farmers for input purchase and ultimately to adopt new technology. However, some farmers have access to credit while others may not have due to problems related to repayment and down payment in order to get input from formal sources. Hence, some farmers avoid farm credit. The survey result indicated that 5.6% of the non-participants and 58.3% of the participants had taken credit .This was statistically significant at 1% level of significance.

Table 4.2 summery of descriptive statistics continuous variables

Variable	Participants		Non-participant		t-test
	Mean	Std.E	Mean	Std.E	
Hhage	44.783	1.184	47.244	1.054	1.5260
Hheduc	5.4	.50	4.14	.41	1.951**
Farmexp	28.9	1.66	23.19	.41	1.951**
Hhsizepa	6.58	.27	5.82	.21	-2.26**
Cultland	4.93	0 .28	2.25	0 .11	-9.855***
Soilfertility	.57	0.06	.39	.05	-2.1591**
Tlu	8.13	.53	4.00	.36	-6.669***
Dismkt	17.36	1.83	15.23	.548	1.2737
Disftc	2.538	.207	4.697	.258	6.0160***
Farm income pa	4315. 95	453.44	1479. 09	94.94	7.3208***
Foodexpa	3377.622	234.368	2130.434	63.53603	-6.0452***

Source: computed own survey

Age mean of the heads of sample respondents was 44.783 years for small- scale irrigation users. For non-users the mean age was 47.244 years. The age difference between the two groups is found to be statistically insignificant suggesting age has no influence on the participation decision. This indicates that as age advances, household heads did not become eager to accept irrigation technology. Therefore, with insignificant critical t-statistic of 1.5260, this shows that increasing participation in the small-scale irrigation scheme would not depend on the farmer's age. Unlike this study Bacha et al. (2011) found that age is a very important continuous variable positively influenced household heads decision to participate in irrigation. The summary result presented in the above table suggests mean education level of irrigation user household heads and non users were 5.4 and 4.1 respectively. It was hypothesized that irrigation participation and education status of the household heads had positive relationship. Educated people are more readily utilize those technologies. This result is consistent with the hypotheses and the previous finding and the survey result shows that there is a positive relationship between educational status of household head and irrigation participation and it is significant at5% level of significance. The survey result reveals that educated people can more easily contribute to the adoption of small-scale irrigation technology and more readily utilize this technology. The education level of household heads is higher for irrigating households than non-irrigating households. This shows households with better educational background are more likely to use small-scale irrigation. This is consistent with Maddison et al. (1970) found that education plays a key role for household decision in technology adoption. It creates awareness and helps for better innovation and invention. It is one of the main factors affecting adoption of irrigation technologies to improve agricultural productivity.

The average farm experience of irrigation users and non-users were 28.9 and 23.19 respectively. The results of this study reveal that this variable is significant at 5% level of significance. This indicates that the average farm experience of irrigation user household heads is higher than the non-users. This shows that as the farm experience of household heads increases by one year the participation of households in small-scale irrigation in the study area increases leads to respondents to raises the probability of being food secure. With regard to household size, the average household size per adult equivalent for the small-scale irrigation users and non-users is found to be 6.58 and 5.82, respectively. This result shows that it is statistically significant telling labor availability is an important factor influencing households' decision to participate in small-scale irrigation schemes. The result also revealed, as active family labor or work force of a household in adult equivalent increases, the total income of the household increases, which in turn contributed to improved well-being, further providing an evidence for the importance of labor availability in influencing the participation decision of households in small-scale irrigation.

The cultivated land size of sample households varies from 1 to 12.5 tsimad. Ownership of cultivated land was hypothesized as the most important factors for difference in irrigation participation between household heads. The research then try to examine whether cultivated land holding per household vary among the sample study areas and household cultivated land holding size has relationship with household irrigation participation. The survey result indicates that irrigation user and non-user households of the study area have an average cultivated land size of 4.93 and 2.25 (tsimad). This shows that land holding has an effect on the participation decision-making behavior of farm households. This difference is statistically significant at 1%. That is, irrigation users possess more land on average than non users. Irrigation may generate income and allow accumulation of other productive assets by irrigating households, which facilitate cultivation of additional land through share in and rent in from non-irrigating households.

Livestock holding have an important role in rural economy. They are source of draught power food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport. Farm animals in the study area also serve as a measure of wealth in rural area. The kinds of animals found in the study area were cattle, sheep, goats, donkeys, honeybees and chicken. As described in (table 4.2), the survey result shows that, the average numbers of livestock holding between the two groups of sample farmers differ. In order to make comparison of the animal size between the farmer groups, the herd size was converted into livestock units (TLU) based on Storck et al. (1991).The number of livestock owned by a household in TLU is calculated by conversion factor for Tropical Livestock Unit (TLU) indicated in the annex . The size of livestock in TLU owned by a household is calculated by multiplying the number of each type of animal by an appropriate conversion factor and then sum up. Farmland and animal resources are important in rural areas. They are basis for technology adoption, household resource endowment and developmental program intervention (Kuwornu et al. 2011). In the study area, the average livestock holding, for irrigation users and non users were 8.13 and 4.00 respectively. The survey revealed that there is a significant difference in livestock holding between irrigators and non-irrigators at a (1%) significance level. This shows it is consistent with the above finding which is livestock holding have positive effect on irrigation participation which leads households with higher livestock holding will lead to higher probability of getting excess livestock for selling and hence generating additional income, particularly the owner of more oxen lead to an ability of ploughing more land on time, thereby achieving crop yields and earning higher income. Farm animals have an important role in rural economy. They are source of draught power food, such as, milk and meat, cash, animal dung for organic fertilizer and fuel and means of transport.

Area with farmers training center access expected the greatest potential for agricultural development. Therefore, distance to FTC is hypothesized to affect land agricultural development negatively. The average distance of irrigation participants and non-participants from their residence to FTC is 2.5and 4.7respectively. This variable is statistically significant at 1% level of significance level. The mean difference between the two groups with regard to distance from the farmers training center is statistically significant at 1% level of significance. This shows the longer the distance from home to the farmer training centers and/or development agent offices, the lower is the probability to use irrigation.

According to the result shown in table (4.2) the average annual farm income, both from cop production and livestock rearing was significantly higher for users of the irrigation scheme in the study area. The average farm income per adult equivalent of the irrigators and non irrigators are ETB 4316 and 1479 respectively. This is the sum of average income from farm production only.. This indicted that small -scale irrigation has statistically significant effect on annual income. But this will be more appropriately tested using econometric analysis. Irrigation is considered as one of the best technologies for ensuring household food security and for sustainable rural development. Irrigation schemes can play a significant role in improving household food security. The household food and total expenditure per adult equivalent was discussed bellow.

The aim of this study was to examine the magnitude of change which had occurred in the annual consumption expenditure by estimating the difference between irrigation participants and non-participants. The result obtained from the survey indicates that the mean annual consumption expenditure of irrigation users, ETB 3377, was significantly higher than the non-users, ETB 2130. This revealed that small scale irrigation has statistically significant effect on consumption expenditure. This significant difference in food consumption expenditure generated by the two groups of households is mainly due to high income of irrigators from increased agricultural production. This revealed that a household above the minimum food consumption expenditure per adult equivalent is considered to be food secure whereas a household below minimum food consumption expenditure per adult equivalent is considered as food insecure which was calculated based on the estimated cost of acquiring the recommended daily calorie allowance, which was taken as 2200 kcal per adult equivalent per day. The nutritional requirements often used are the international standards set by the World Health Organization (WHO) and the Food and Agricultural Organization (FAO). This cut-off value is estimated to be Birr 1985 per adult equivalent per annum for 2010/2011. Therefore, households having food consumption expenditure per adult equivalent of less than Birr 1985 are considered as food insecure, while those more than Birr 1985 are considered to be food secure. Based on this, the descriptive analysis indicates irrigators are better off in terms of food security status (table 4.2). But it is difficult to conclude this difference is due to access to irrigation because other observable and unobservable variables might have contributed to food security status difference between irrigators and non-irrigators. Therefore, Heckman two stage regressions were employed to determine the impact of small-scale irrigation on rural household food security (holding other observable and unobservable confounding factors constant).

4.2 Problems encountered in small-scale irrigation development

The significance of irrigated agriculture in the study area has increased. It has become a major means food security. The survey result found that small-scale irrigation has a great potential to improve the incomes of poor rural households accompanied with many problems. The major problems associated with small-scale irrigation in the study area are problems related to cost, lack of sufficient irrigation water, lack of effective marketing system, lack of input supply and irrigation facilities, and presence of pests and diseases. The importance of irrigated agriculture in the woreda has significantly increased. This study identified several irrigation constraints using the small-scale irrigation participants in the study area. Table(2) shows that shortage of financial for farm inputs is a major problem for 30% of the irrigation user respondents while, incidence of pest and diseases, lack of sufficient irrigation water, and lack effective market price system, of the treatment respondents were 20%,13.33%,13.33% and 23.23 respectively (table 4. 3).

Table 4.3 Main constraints of irrigation agriculture by irrigation participant's survey

Major problems of irrigation sector	Irrigation participants	
	Obs.	Percent
shortage of financial for farm inputs	18	30
incidence of pest, diseases, etc	12	20
lack of sufficient irrigation water	8	13.33
lack effective market price system	8	13.33
lack awareness about irrigation	14	23.23
Total	60	100

Source: Survey output 2014

4.3 Foster Greer Thorbecke (FGT) poverty indices result

The Foster Greer Thorbecke (FGT) poverty indices show that the small-scale irrigation participants are better-off than non-participants. Using the poverty line of ETB 1985 in table (4.4) indicates that poverty incidence was lower among irrigation participants compared to non participants, with35.5% of non-participants in the study area classified as poor compared to26.3% of irrigation participants.

The study area practices 31.6% levels of poverty as shown in (table 4.4) poverty incidence. The depth and severity of poverty was higher among the non-irrigators than among irrigators. The poverty gap index is 8.2% for non-irrigators and 3.1% for irrigators. This implies that the current food consumption level of poor irrigation users and non-users would have to increase by an average of 8.2 % and 3.1%, respectively, to lift them out of poverty. The squared poverty gap index show that inequality among the poor is higher for non-irrigators than it is for irrigators. The FGT poverty indices also indicate that although poverty is common for both groups it is more marked among non-irrigators. The next section provides econometric models that were used to examine the extent to which irrigation increases household consumption, holding other factors constant.

Table 4.4 FGT Poverty indices

	Participant	Non-participant	Total sample	Poverty line
Poverty head count index(α=0)	0.263	0.355	0.316	ETB 1985
Poverty gap index(α=1)	0.030	0.083	0.060	
Squared poverty gap index(α= 2)	0.005	0.023	0.015	

Source: computed own survey, 2014

4.4 Econometric Result

In the descriptive analysis part of this thesis the important explanatory variables, which are expected to have effect on households decision to small-scale irrigation participation were presented. In this section, the selected explanatory variables were used to analyze the determinants of small-scale irrigation participation and outcome using Heckman model.

4.4.1 Determinants of small-scale irrigation participation

4.4.1.1 Robustness check

In this study probit model was used to analyze the determinants of small-scale irrigation participation. Which is the rural households either participate or not participating irrigation activities. Consequently, the variable to show participation in small-scale irrigation was used as a binary dependent variable, taking a value "1" showing the household is participating and "0" otherwise. Before starting analysis, Multicollinearity and heteroscedasticity tests were done to determine the association among the independent variables. The problem of heteroscedasticity and multi-collinearity are very common in cross-section data. The data should be cleared before it is used for purpose of analysis. Moreover, using the box plot graph and histogram identifies the outliers and the most frequent observation is assigned for each site so that details do not get lost.

The presence of heteroscedasticity is detected by using the Brush Pagan test. This problem is addressed by calculating the robust standard error for the probit regression model. VIF also shows how the variance of an estimator is inflated by the presence of multicollinearity

(Gujarati, 2003). There are two types of measurement employed to test the existence of multicollinearity. These are: Variance Inflation Factor (VIF) which shows how the variance of an estimator is inflated by the presence of multicollinearity and contingency coefficients for dummy variables. This indicates that how multicollinearity inflated the variance of an estimator (Gujarati, 2003). As a rule of thumb, if the VIF of a variable exceeds 10, there is multicollinearity. To avoid serious problems of multicollinearity, it is quite essential to omit the variable with value 10 and greater than 10 from the model specification. Therefore, the variance inflation factor (VIF) was employed to test the degree of multicollinearity among the continuous variables. As shown in the annexed(5), the values of the VIF for the continuous variables were found to be small (i.e. VIF values less than 10), indicating the data have no serious problem of multicollinearity. Similarly, the contingency coefficient, which measures the association between various categorical variables based on the Chi square, were computed in order to check the degree of association or the existence of multicollinearity problem among the categorical explanatory variables. The decision rule for contingency coefficients states that when its value approaches 1, there is a problem of association between the dummy variables, i.e., the values of contingency coefficients ranges between 0 and 1, with zero indicating no association between the variables and values close to 1, indicating a high degree of association.

Based on the above conditions, the result of the multicolinearity for both participation equation and outcome equation shows that the values of the VIF for the continuous variables were found to be small (i.e. VIF values less than 10), indicating the data have no serious problem of multicollinearity. Similarly, there was no problem of association among the dummy variables. Therefore, after checking of it, model analysis was conducted.

Because of the various encouragements from the government, the number of farmers in the study area who are participating in small-scale irrigation has increased. However, still there are several farmers who don’t participate in irrigation. For example, some farmers who have irrigated land don’t participate in irrigation where as some farmers with no irrigated land participate in irrigation in the study area. This implies that irrigation decision is not an easy and is made within a wider context. In this sub section, we treat results concerning food consumption expenditure at household level as well as the socio economic, demographic and other factors that affect the food expenditure behavior of households' .This study identified the potential factors that motivate farmers to practice irrigation farming using the participation probit model.

4.4.1.2 **Heckman selection model**

The first stage of the Heckman model *(Heckman selection model*) predicts the probability of the irrigation participation of a household. The results from the estimation presented in the table below show that the observable hypothesized variables, such as household head sex, household head education level, cultivated land, distance to farmers training center(FTC), access to extension service, access to credit and water availability are significantly influenced the probability of participating in small-scale irrigation. Except distance to FTC, the positive sign of the coefficients indicate that the explanatory variables estimated influence the dependent variable positively. However, distance to FTC influences the dependent variable negatively. The level of significance varies from one independent variable to the other. In testing of the hypothesis H0: b=0 against the alternative H1: b is different from zero; sex, education level and credit are significant at 10% significant level. Cultivated land, distance to FTC and access to extension services are significant at 5% level of significant level and sex, education and credit are significant at 10% significance level. But irrigation water availability of the household head is significant at 1% significant level. In what follows, the effect of the explanatory variables on small-scale irrigation participation of the household in the study area is discussed below. The results from the estimation of the factors affecting adoption of small-scale irrigation are presented in (table 4.5). Many of the explanatory variables have the expected sign all statistically significant variables show the expected sign for impact on irrigation adoption. The result in table 3 indicates that, jointly, all estimated coefficients are statistically significant since the LR statistic has a p-value less than 1%. The pseudo R^2 value is 81.7%, which is high for cross-sectional data.

Another measure of goodness of fit of the model is based on a scheme that classifies the predicted value of events as one of the estimated probability of an event is equal or greater than 0.5 and 0 otherwise. From all sample farmers, 95 were correctly predicted in to irrigation participants and non-participants categories by the model. The correctly predicted participants (sensitivity) and correctly predicted non-participants (specificity) of the model were 93.3%nd 96.7% respectively. Thus, the model predicts both groups accurately. The link test command performs a model specification link test for single-equation models was also conducted to check if a regression is properly specified. Hence, _ hatsq is insignificant this is to say the model is correctly specified (table 4.5).

Table4.5 Estimation result of the Binary Probit model and it's Marginal Effect (participation equation)

Variable	Coefficient	Z	P>|Z|	Marginal effect
Constant	-6.918**	-2.18	0.030	-6.918*
Hhsex	1.344*	1.72	0.085	.415*
Hhage	-.046	-0.93	0.353	-.014
Hheduc	.181*	1.65	0.099	.056*
Hhsizepa	.093	0.56	0.577	.029
Farmexp	.043	0.90	0.368	.013
Cultland	.688**	2.28	0.023	.213**
Soilfertilitiy	.052	0.09	0.927	.016
Tlu	-.016	-0.23	0.816	-.005
Dismkt	.047	1.07	0.286	.014
Disftc	-.291**	-2.02	0.043	-.090**
Accexten	2.027**	2.06	0.039	.493**
Credit	1.567*	1.68	0.093	.539*
Wateravai	1.867***	2.90	0.004	.503**
Dependent variable	Irrigation participation			
Weighting variable	One			
Number of Observations	150			
Likelihood function	164.98			
Degree of freedom	13			
Significance level(Prob > chi2)	0.0000			
Pseudo R2	.817			
Correctly predicted participant	93.33%			
Correctly predicted non-participant	96.67%			

Over all cases correctly predicted	95.33%
_hatsq	0.447
Level of significance	Sign
At 10 percent	*
At 5 percent	**
At 1 percent	***

Source: Model output, 2014

Household head sex: among the demographic variables, household head sex appeared to be significant in determining household's participation in small-scale irrigation schemes in the study area. This variable is significant at 10% significance level and positively associated with the adoption of small-scale irrigation. It is interesting to note that within the sample, holding all other factors constant, male headed households are found more likely to adopt small-scale irrigation than their female counterparts. This result is consistent with the hypothesis that small-scale irrigation is attractive to male headed households. This shows that those farmers with male are more likely to participate in irrigation technology (controlling other variables table (4.5). Like this study the study by Dillon (2011) found that gender of the head is a variable that statistically and significantly explaining the participation in irrigated agriculture.

Household head education level: This variable is significant at 10% level of significance level and it has positive association with irrigation participation. The relationship between household head education level and participation in small-scale irrigation program shows that 1 extra year of education raises the probability of being in small-scale irrigation participation by 5.6 percentage points (holding other influencing variables constant) .This variable as hypothesized affects the household's participation decision in irrigation in such a way those households who educated better chance to adopt small-scale irrigation. The same result the study by Asayehegn et al. (2011) found that education plays a key role in household decision for technology adoption.

Cultivated land size: This variable is significant at 5% level significance and has a positive relationship with irrigation participation. The result shows as the size of cultivated area increases by one tsimad, the probability of being an irrigator increases. That is cultivated land size motivates households to adopt irrigation. The implication is that the probabilities of being irrigator increases with farm size (controlling other variables constant).

Distance to farmers training center: The model result shows that the coefficient of this variable has positive relationship with irrigation participation and it is statistically significant at 1% significance level. This indicates that households nearer to the farmers training center are more likely to participate in small-scale irrigation in the study area. This is consistent with Moll (2004, found that the farmer training center is a source of information for the tabia resident. There are development agents in the tabias who teach the local communities about the application of the new technologies. The longer the distance from home to the farmer training centers and/or development agent offices, the lower is the probability to start and use irrigation.

Access to extension service: The model result reveals that this variable has a significant (at 5% level) and positive influence on the small-scale irrigation in the study area. The possible explanation is that those farmers who have access to extension service are more likely to adopt small-scale irrigation than who have not access to extension services (holding other variables constant). This may due to irrigation participants who get technical advice and training or those are well aware of the advantage of agricultural technologies and adopt new technologies. This result is consistent with findings by Gebregziabher et al. (2009).

Access to credit: As indicated in the table there is systematic association between irrigation participation and credit access. This variable is significant at 10% level of significance and positively associated with the adoption of small-scale irrigation. The positive relationship could be because those households who have access to credit have a better possibility of getting farm inputs. Credit helps farmers purchase inputs such as seeds, fertilizers. Therefore the probability of participation in small-scale irrigation increases. The regression results shows that in the study area household decision to participate in small-scale irrigation is more significantly affected by the volume of credit received. Respondents who have credit access are more likely to adopt small-scale irrigation technology than respondents who have not the access (holding other influencing variables constant Variables constant).

Water availability: The model measures the relation between this variable and small-scale irrigation participation. This variable positively influenced the irrigation participation of the households. The results suggest that having an irrigation water supply on the household farm improves the irrigation participation at 1% level of significance level. This can be justified by the fact that getting irrigation water supply, farmers will improve irrigation participation of the rural households in the study area. Especially, smallholders can enable to grow food crops a minimum of twice a year, hence increased consumable food source of the household. So, it overcomes insufficiency of food availability mainly in drought or food shortage circumstance at large. Source: Compute own survey, 2014

4.2.2 Heckman Outcome model

4.4.2.1 Determinants of household food consumption expenditure

To examine the impact of small-scale irrigation on rural household food security further analysis was done using heckman two step model. The second stage of Heckman's procedure also referred to as the outcome equation uses Ordinary Least Square (OLS) for analyzing the determinants of households' food consumption expenditure. The likelihood function of the Heckman model two-step was significant indicating a strong explanatory power and the coefficient of the Inverse Mills Ratio (IMR) was insignificant providing indication of the absence of self-selection leading to use the Heckman's two-step procedure. In practice both income and expenditure are used to measure the impact of small-scale irrigation on household food security. However, in developing countries the use of expenditure is considered more appropriate than using income due to the fact that households are more likely to under report their income than their consumption (Ravalion, 1998).Therefore, food consumption expenditure data was used to determine the impact of small-scale irrigation on rural household food security.

Depending on economic theories and data availability, the variables believed to influence the food consumption expenditure of the farming households have been included. To avoid identification problem that could arise during estimation, the variable distance from the households' residence to the farmers training center and irrigation water availability have been excluded from the outcome equation and used only in the selection equation. An assumption required to guarantee reliable estimates of the outcome equation is the existence of at least one additional explanatory variable with a non-zero coefficient in the selection equation which has no direct effect on the outcome (Heckman and Vytlacil, 2005). Including the same number of variables in the selection and outcome equations would lead to the multicollinearity problem in the outcome equation which results in very imprecise estimates (Sartori, 2003). Therefore, participation equation included two variables more than the food consumption expenditure equation for model identification purposes.

The correlation of this variable with other variables in the income equation is tested and the test result revealed that this variable doesn't have correlation with any one variable in the income equation. However, it doesn't mean that the variables included are exhaustive. Hence, out of the 12 explanatory variables 8 variables are found to be significant. These determinant factors of food consumption expenditure are household size per adult equivalent, cultivated land size holding, soil fertility, livestock holding, distance to market, access to credit, and access to extension service.

Table4.6 Estimation Result of the Heckman Outcome Equation (*food expenditure equation)*

Variable	Coefficient	T	P-value
Constant	862.428	1.09	0.276
Hhsex	190.448	1.06	0.292
Hhage	-6.416	-0.65	0.518
Hheduc	65.613	1.63	0.106
Farmexp	-3.891	-0.46	0.649
Hsizepa	-206.584***	-4.48	0.000
Cltland	225.737**	2.47	0.015
Soilfertil~y	259.925*	1.93	0.056
Tlu1	154.197***	5.17	0.000
Credit	372.415	1.40	0.164
Dismkt	52.685***	2.65	0.009
Ecexten	396.236*	1.94	0.055
Invmills	-97.756	-0.26	0.792
Dependent variable	Food expenditure per adult equivalent per annum		
Selection rule is	Participant=1		
Number of observation	150		
F(12, 137)	17.34		
Prob > F	0.0000		
R-squared	0.7120		
Root MSE	853.33		
Source: model output 2014			
Level of significance	Sign		
At 10 percent	*		
At 5 prcent	**		
At 1 percent	***		

Source: Model output, 2014

According to the summarized model results shown in the above table possible explanation for each significant independent variable is given as follows. As indicated in the above table R^2 value of 0.714 points to the fact that at least 71.4% of the variation in outcome is explained by the variation of the independent variables. Thus, approximately 71.4% of the changes experienced in food expenditure are explained by the variation of the household size per adult equivalent, cultivated land size, soil fertility, livestock holding (tlu), distance to market, access to extension services and access to credit of each household head involved in this study. The closer Adjusted $R^2$is to 1, the better is the fit of the estimated regression line.

In testing the hypothesis that H0: b1, b2,b3,b4,b5,b6 …=0, against the alternate hypothesis H1: b1, b2, b3, b4, b5, b6 is different from zero, the F statistics was employed. The F value obtained from the model result is significantly different from the critical value of F at 12 and 137 degrees of freedom respectively, at significance 1% level. This can, thus, entail that the explanatory variables included in the model jointly influenced household food security. The model output revealed that the null hypothesis is rejected.

Inverse Mills ratio (lambda): As indicated in the above model output table, the inverse Mills ratio term is insignificant indicating the absence of selectivity bias. The negative sign shows that the error terms in the participation and outcome equations are negatively correlated. This suggests that those unobserved factors that make the household participate in small-scale irrigation are likely to be negatively associated with household food consumption expenditure.

Family size of the household: The Heckman output result for the variable household size per adult equivalent shows that food expenditure per adult equivalent have negative relationship with household size per adult equivalent and significant at 1% level of test. The coefficient of the variable indicates that as the household size increases by one adult equivalent the food consumption expenditure of the household decreases by ETB 206.6 (other things remaining constant). It is probably due to an increase in household size decrease cultivated land per capita and in return decreases the availability of enough food for a household. This result is consistent with the finding of Yilma (2005).

Cultivated land size: In this study it was expected that a larger size of cultivated land will have more chance of being food secure at household level. The regression result also shows that as the cultivated land size increases, a household is able to increase and diversify the quantity and type of crop produced, which may in turn lead to increased consumption and household food security. The coefficient of the land size variable is significant at 5% level of significant and positively influenced the food consumption expenditure per adult. The result shows that as the household get one more tsimad of land, food consumption expenditure per adult per annum increases by ETB 225.7 (keeping other variables constant). This result is consistent with findings Abebaw (2003).

Soil fertility (soilfertility): The quality of land owned by a farmer in this study indicates that it has a positive relationship with food security status. That is households with fertile land are food secure than households with infertile land. Soil fertility variable has a positive influence on food security at 10% significance level. The result of the analysis shows that as the land quality of the farmers becomes fertile the consumption expenditure per adult equivalent increases by ETB 259.9 (holding other variables constant).

Livestock holding (tlu): Livestock holding is among the most important factors of production and as it was expected it determine household food security status of the study area. It is the fact that an ox is the only input of draft power for land preparation in their crop farming system. Hence, it has significant contribution in supplying of food grain for the household members. The regression result shows this variable is significant at 1% significance level. The positive effect of livestock holding indicates that in the study area, those who have more livestock thereby improving the food consumption expenditure leads households food secure. The study result revealed that, a unit TLU increase in livestock holding would increase on average the total food expenditure of a household by 154.2, while keeping all other variables constant at their mean value. This means that as the ownership of livestock of respondents increases by one unit the food consumption expenditure per adult equivalent increases by ETB 154.2. That is the more the number of livestock available to households the larger is the probability of being food secure. The positive sign of this variable indicates that the contribution of livestock ownership towards ensuring food security (holding other variables constant). This is consistent with Kebede(2011).

Distance to market (dismkt): This variable also found that it is statistically significant at 1% significance level and positively influence to food consumption expenditure. This implies that as the distance of the market increases by (1 km), the food consumption expenditure per adult equivalent increases by Birr 52.8. The positive effect of distance to market may indicate that in the study area, those households far from the market provide them to consume more food than put on the market and thereby improving their food security (keeping all other variables constant at their mean value).

Access to extension service (accexten**):** Use of inputs influences household income from crop production. The result of Access to extension service found to have a positive relationship with household food consumption expenditure and it is significant at 10% significant level (table 4.7). The positive effect of access to extension service may indicate that in the study area, those households who get technical advice and training are well aware of the advantage of agricultural technologies and adopt new technologies and produce more, thereby improving the household food security status (controlling other variables constant).

As indicated in table(4.7) Heckman two stage outcome results revealed that the treated group households have on average ETB 2556.8 more than the control group in consumption expenditure per adult equivalent per year. The reason for having better food consumption expenditure is farmers participating in small-scale irrigation get more farm income to overcome insufficiency of food availability mainly in drought by growing crops a minimum of twice a year, hence increased consumable food source of the household. Finally the overall evaluation of the study presented that by the food consumption expenditure and implication on food security, the treated groups are in better position than the control group. This implies small-scale irrigation has significant effect on both farm income and food security status of irrigation participants as compared to the non-participants.

Table 4.7 Mean difference of food expenditure per adult equivalent per annum

Variable	Mean	Std.dev	Min	Max
Foodexpa	2556.763	1286.529	-116.307	7912.147

Source: computed from own survey, 2014

Chapter 5: CONCLUSIONS AND RECOMMENDATIONS

The objective of this study was to assess the impact of small-scale irrigation on rural household food security. The study was conducted in Emba Alaje Woreda of Southern Zone of Tigray regional state, Ethiopia, focusing on small-scale irrigation.

5.1 Conclusions

The hypothesis of this study was small-scale irrigation scheme has a positive impact on households' farm income and household food security using consumption expenditure as a proxy. Hence, this study investigates that the main factors that explains rural households to participate in small-scale irrigation using participation probit model. The finding of the study describes sex, education level, cultivated land holding, access to credit, access to extension service, distance to farmers training center and irrigation water availability of the household heads are the major factors that significantly influence the probability of rural households to participate in small-scale irrigation. These all variables were positively influenced the irrigation participation of the household heads in the study area. For instance, the positive relationship access to credit and access to extension service with small-scale irrigation participation explained by the fact that the institutional credits and extension services gives an opportunity to households to participate in small-scale irrigation. The mean cultivated land size of small-scale irrigation users and non-users was 4.93 and 2.25 (tsimad) respectively. This indicates that more access of cultivated land to irrigation user households enables them to participate in small-scale irrigation and generate more farm income than non-user. In the same way the average education level irrigation users and non-users was 5.4 and 4.14(years) respectively. This show that one extra year of schooling to irrigation participants allows them to participate in small-scale irrigation schemes than non-participants.

The study also estimated the impact of the small scale irrigation on rural household annual income and food security status. The result of descriptive statistics shows that the annual farm income and food consumption expenditure per adult equivalent of the irrigation participants in 2012/2013 were respectively 48.9% and 36.4% higher than that of the non-participants. The FGT result indicates that the poverty incidence was higher among irrigation participants compared to non participants, with35.5% of non-participants in the study area classified as poor compared to26.3% of irrigation participants. The study area practices 31.6% levels of poverty as shown in (table 4.4) poverty incidence. The depth and severity of poverty was higher among the non-irrigators than among irrigators. The poverty gap index is 8.2% for non-irrigators and 3.1% for irrigators. This implies that the current food consumption level of poor irrigation users and non-users would have to increase by an average of 8.2 % and 3.1%, respectively, to lift them out of poverty. The squared poverty gap index show that inequality among the poor is higher for non-irrigators than it is for irrigators. The FGT poverty indices also indicate that although poverty is common for both groups it is more marked among non-irrigators. The next section provides econometric models that were used to examine the extent to which irrigation increases household consumption, holding other factors constant

According to the Heckman two steps, household size per adult equivalent, cultivated land holding, soil fertility, livestock holding, and distance to market, access and access to extension service are the determinants of food consumption expenditure status of the household heads.

Finally the result of this study indicates that small-scale irrigation development has a positive impact on food security status of rural households. The food security analysis indicates that a much higher proportion of those who are poor are non-irrigating rather than irrigating households. Thus, the food insecurity occurrence in non-irrigating households is greater than in irrigating households. This suggests that small-scale irrigation has an important influence on rural household food security. This analysis shows that use of small-scale irrigation reduces the probability of a household being poor, controlling other factors.

5.2 Recommendations

In the study area still there are many rural households which are not participating in small-scale irrigation. This is because of lack of irrigation water availability, lack of education, lack credit access, lack of extension services and other awareness enhancing systems. Based on the findings of this study the following general recommendations are given:

- Organize capacity-building activities to advance the farmers' participation in small-scale irrigation to upgrade their existing indigenous way of management system.
- Expanding the capacity of small-scale irrigation agriculture and creating additional access through integrated water investment is important to increase agricultural product and hence leads to increase household's food security.
- Traditional river diversion should convert in two modern river diversions in order to reduce water loss in the earth canals and hence increasing irrigation participants in the study area.
- Credit systems in rural areas should be in place for input supplies and low cost technologies acquirement, which are directly applied to the farm. It is necessary to provide farmers with inputs for the first season, so that they can build a cash flow base and start producing their own seed.
- Training in water management, marketing and general crop production is important for new and old irrigation schemes.
- Encouraging female headed households to participate in small-scale irrigation using special trainings, credit access and extension services. Because in this result found that male headed households are more likely to participate in small-scale irrigation than female headed households.
- Expansion and promotion of family planning programs since household size affect negatively their food security situation.

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ANNEXES

Annex 1.Conversion factor for Adult equivalent

Years of age	Men	Women
0-1	0.33	0.33
1-2	0.46	0.46
2-3	0.54	0.54
3-5	0.62	0.62
5-7	0.74	0.70
7-10	0.84	0.72
10-12	0.88	0.78
12-14	0.96	0.84
14-18	1.14	0.86
18-30	1.04	0.80
30-60	1.00	0.82
Above 60	0.84	0.74

Source: Dercon and Krishnan (1998)

Annex2 Conversion factor for Tropical Livestock Unit (TLU)

Livestock Type	TLU
Ox	1.00
Cow	1.00
Heifer	0.75
Bull	1.00
Calves	0.25
Sheep	0.13
Goat	0.13
Donkey	0.70
Horse	0.75
Poultry	0.013

Source: Abdinasir, Ibrahim (1991)

Annex3 Variance Inflation Factors (VIF) of Continuous variables

Variable	VIF	Tolerance
farmexp	2.88	0.346797
hhage	2.31	0.433074
tlu1	2.12	0.471296
cultland	1.90	0.525160
hheduc1	1.67	0.597775
Avaiwater	1.58	0.634269
accexten	1.56	0.641913
Credit	1.55	0.645216
Disftc	1.37	0.729669
hhsizepa	1.37	0.731203
hhsex	1.14	0.875642
soilfertil~y	1.11	0.897724
Dismkt	1.06	0.940619
Mean VIF	1.66	

Source: Model output

Annex 4 Contingency Coefficients for Discrete Explanatory Variables

```
       pwcorr  hhsex  soilfertility accexten credit avaiwater


             |    hhsex soilfe~y accexten   credit avaiwa~r
-------------+---------------------------------------------
       hhsex |   1.0000
soilfertil~y |  -0.0268   1.0000
    accexten |  -0.0965   0.1593   1.0000
      credit |  -0.0000   0.0484   0.3408   1.0000
   avaiwater |  -0.0269   0.0905   0.3710   0.4738   1.0000
```

Annex 5 Estimation result of the heckman selection model (participation equation)

irrigpartici	Coef.	Std. Err.	z	P>|z|	[95% Conf.	Interval]
hhsex	1.343726	.7794752	1.72	0.085	-.1840176	2.871469
hhage	-.0463098	.0498425	-0.93	0.353	-.1439992	.0513796
hheduc1	.1816642	.1102065	1.65	0.099	-.0343365	.3976649
hhsizepa	.0934452	.1673315	0.56	0.577	-.2345186	.4214089
farmexp	.0427301	.0475128	0.90	0.368	-.0503931	.1358534
cultland	.6884752	.3018797	2.28	0.023	.0968017	1.280149
soilfertil~y	.0516902	.5609348	0.09	0.927	-1.047722	1.151102
tlu1	-.0162518	.0697889	-0.23	0.816	-.1530355	.120532
dismkt	.0465767	.0436746	1.07	0.286	-.0390239	.1321773
disftc	-.29147	.1440059	-2.02	0.043	-.5737164	-.0092236
accexten	2.026919	.9832187	2.06	0.039	.0998453	3.953992
credit	1.56704	.9319742	1.68	0.093	-.2595961	3.393675
avaiwater	1.866669	.6427907	2.90	0.004	.6068219	3.126515
_cons	-6.918011	3.178648	-2.18	0.030	-13.14805	-.6879748

Annex 6 estimation result of heckman output equation

foodexpa	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
hhsex	190.4482	180.0119	1.06	0.292	-165.5128	546.4093
hhage	-6.415951	9.908899	-0.65	0.518	-26.01012	13.17822
hheduc1	65.61349	40.34624	1.63	0.106	-14.16842	145.3954
farmexp	-3.891291	8.53237	-0.46	0.649	-20.76346	12.98088
hhsizepa	-206.5838	46.07499	-4.48	0.000	-297.6939	-115.4737
cultland	225.7371	91.46196	2.47	0.015	44.87733	406.5968
soilfertil~y	259.9248	134.9292	1.93	0.056	-6.888369	526.738
tlu1	154.1967	29.83715	5.17	0.000	95.1958	213.1976
credit	372.415	266.0558	1.40	0.164	-153.692	898.522
dismkt	52.68453	19.86963	2.65	0.009	13.3937	91.97536
accexten	396.2357	204.7068	1.94	0.055	-8.557958	801.0293
invmills1	-97.75579	369.3285	-0.26	0.792	-828.0775	632.5659
_cons	862.4275	788.3221	1.09	0.276	-696.4252	2421.28

Annex 7 Research questionnaires

The impact of small-scale irrigation on rural household food security on Emba Alaje Woreda".

Tabia ________________Kushet_____________________

Section One: Household Demographics

1.1 Households composition, education and occupation. (Please fill all your family members in the given table by using codes given below the Table)

No	Name	Sex	Age (year)	Marital Status	Relationship to HH- head	Years of schooling	Major occupation	
							Primary	Secondary
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								

Variable codes

Sex: 1=Male 2=Female

Marital status: 1=Single 2=Married 3=Divorced 4=Widowed 5=others_______________

Relationship to household head: 1=Head 2=Husband 3=Wife 4= Daughter 5= Son 6=Grandchild 7=Parent 8=Laborer 9=Sister 10=Brother11=Step child 12= others___________

Years of schooling: 0=Illiterate 1=Religious school 2= 1^{st}gradecomplete 3=2^{nd}grade complete 4=3^{rd}grade complete 5=4^{th}grade complete 6=5^{th}grade complete etc

Occupation: 1=Farmer 2=Trader 3=Housewife 4= Constructio5=Weaving 6=Carpentry 7=Student 8=herding 9=others (specify) _________

Section Two: **Household assets**

2.1 Land owned

2.1.1 Please list the land owned by your family and fill the codes for use of plot and, soil quality and slope of land from the variable code given under the table.

No	Name of plot	Plot size (Tsimad)	When did you obtain this land(year)	Use of the plot during the last one year	Soil quality	Slope of the plot
1						
2						
3						
4						
5						
6						
7						

Variable codes;

Use of plot land: 1=Own cultivated 2=owned but cultivated by others household (sharecropped) out 3=Owned but cultivated by other hh(Rented out)4=Grazing land Others(specify.____________________

Soil quality: 1=fertile, 0= Infertile

Slope of the plot: 1=medda 2=Gebo 3=Geddel

2.2 Livestock holding: Number and value owned during the last one year.

Type of livestock	Number owned and present at your farm	If you would sell, how much you receive in the last year? (Birr)	Total value(Birr)
Young bull			
Oxen			
Cows			
Heifer			
Calves			
Sheep			
Goats			
Horses			
Mules			
Donkeys			
Camels			
Poultry			
Others(specify)			

Section Three: Household activities and Income

3.1 Farming

1. Did you have communal grazing land? A. Yes b. No
2. If yes, total area of land covered by grass _______________(in tsimad)
3. How many years since started farming (Farming experiences)? __________years
4. Did all your household members participate in farming work? b. Yes b. No

5. If no, how many of them participated? ______________(in number)
6. Did you face labor shortage? a. Yes b. No
7. If yes, how did you solve the problem of labor shortage? a. Hiring b. Labor exchange c. Other_________
8. Total area of land cultivated during the last one year (2005 E.C) _________________ (in tsimad).

3.1.1 Inputs

1. Please fill the activity you did in the last one year in the table given bellow

Activity	Ploughing	Value(Birr)	Weeding	Value(Birr)	Harvesting	Value(Birr)	Total value(Birr)
How many day did you do this activity(labor cost)							
Oxen days							

9. Total area of land cultivated during last year on which fertilizer was used_______(in tsimad)
10. Total area of land covered by improved seeds during the last one yea___________ (in tsimad).

2. Please indicate the activity given in the table below.

No	Activity	Yes=1	No=0	Amount	Unit	Source	Value (Birr)
1	Did you use any manure from your herd on your field?						
2	Did you purchase any fertilizer for use on your field?						
3	Did you purchase improved seeds for use on your field?						
4	Total						

3.1.2 Crop output and sales during rain fed agriculture

Variable codes:
White Teff=1 Peas=2 Beans=3 Red Teff =4 Barley=5 Wheat=6 Maize=7 Sorghum= 8 Oats= 9 Groundnuts=10 Sesame =11 Line seed=12 Pulses =13 Vegetables=14 Coffee =15 Chat=16 Bananas =17 Geshu=18 Papaya =19 Avocado =20 Orange =21 Lemon=22 Guava =23 Potatoes =24 Onion=25 Grass =26 Ananias=27 other =28(specify) ________________

1. Please indicate the amount of food production you got from rain fed agriculture only in the last one year in the table given below by using the above codes.

Plot name	Crop type	Yield (kg)	Values(Birr)	For own consumption(kg)	Values(Birr)	For sale(kg)	Value (Birr)	To others as payment for rent or gift(kg)	Values(Birr 0	Total value(birr)

Section Four: Irrigation capacity

1. Does any household members has irrigable land? a. Yes b. No
2. If yes, what is the size of the irrigable land________________ (in tsimad)?
3. When did you own this irrigable land? a. Before1year b. Before 2 years c. Before 3 years d. Other__________
4. How many times do you produce per year using irrigation? ____________
5. What is the source of water for your irrigation? a. Rivers b. springs c. Ponds d. Wells e. Other____________
6. What is the approximate distance of main water source from centre of plot? __________ (in km).
7. Please fill the activities you did in the last one year in the following two tables given bellow.

7.1

Activity	Plot Name	Plot size(tsimad)	Irrigating	Value(Birr)	Ploughing	Value(Birr)	Weeding	Value(Birr)	Harvesting	Value(Birr)	Total Value(Birrr)
Labor input											
Oxen days											
Total											

7.2

No	Activity	Yes =1	No=0	Amount	Unit	Source	Values (Birr)
1	Did you use any manure from your herd on your field?						
2	Did you purchase any fertilizer for use on your field?						
3	Did you use chemicals to kill pests if you had a problem?						
4	Did you purchase improved seeds for use on your field?						
5	Total						

4.2 Crop output and sales out of irrigation agriculture

8.1Please indicate agricultural product you got from irrigable land only in the last one year.

Crop type(see codes on page 3)	Yield (kg)	Value (Birr)	For own consumption (kg)	Value(Birr)	For sale(kg)	Value(Birr)	To others as payment for rent or gift(kg)	Value (Birr)	Total value(Birr)

4.3 Other sources of Income

8. Do you or your household members under take some additional income generating activities of off farm in the last one year? a. Yes b. No
9. If yes, indicate the income earned from other activities in the table below.

Source	Value(Birr)
Non-farm employment	
Farm work	
Hiring out oxen	
Renting/sharecropping out land	
Sale of firewood/charcoal	
Sale of beverages	
Petty trade (net profit)	
Handcrafts	

Livestock and livestock output trade	
Sale of local drinks	
Weaving	
Food aid	
Sale of livestock output (eg. fluid milk, Butter, Cheese, Chicken, Egg, Honey, Bees wax, etc.)	
Others(specify	

Section Five: Agricultural Extension, Credit, Marketing and other institutional Support services

5.1: Agricultural Extension

10. Is there farmers training center (FTC) in your Tabia? a. Yes b. No
11. How far is the FTC from your home ________________ in Km?
12. How long do you take from your home to FTC______________ in minutes?
13. Did you have some social position in the community? a. Yes b. No
14. If yes, what is your position? ____
15. Did you have some Social Networks in the community? a. Yes b. No
16. If yes, what is your Social Network? A. Edir b. Equib c. Unions d, cooperatives e. Other___________________
17. Is there an Agricultural Development Agent in your Tabia? a. Yes b. No
18. If yes, had you get an extension support during the last one year? a. Yes b. No
19. If yes, have you participated in the training program organized last year? a. Yes b. No
20. If yes, in which topics you had been trained from the lists mentioned in the table below (see codes listed under the table).

Training topics	How many rounds you have been trained (numbers)	For how long you have taken (days)

1=livestock production 2= fruits and vegetables 3=crop diversification 4=marketing 5=irrigation 6=post harvest processing 7= storage of farm produce 8=farm management 9= credit 10= household food security ……15=others

5.2: **Market information**

21. Did you get market information about prices and conditions of agricultural inputs and out puts? a. Yes b. No
22. If yes, what is the source information? a. Radio b. Television c. Newspaper d. Mobile e. Others________________
23. Where did you sell your product? a. At village market b. At district market c. At regional market d. At national market e. Others (specify) ______________________________

24. What is the distance of your residence from the market ___________________ (in Km)?
25. What means of transport do you use to transport your product to the market? a. vehicles b. Animal labor c. Human labor d. Others (specify)_________________________
26. When did you sell most part of your produce? ___________________ (months)
27. Did you get fair price for your produce at this particular time? a. Yes 2. No
28. If no, what are the reasons? a. No demand b. More supply c. Others(specify)_______________
29. Why did you sell at that particular time? a. To appropriate family requirements b. To pay debts c. Other________

5.3 Credit system

30. Had you receive any credit in the past one year? a. Yes b. No
31. If yes, for what reason (s)? a. Purchase of seeds b. Purchase of fertilizer c. purchase of oxen d. for family consumption e. Others(specify)______________________
32. When do you usually take the credit? ___________________ (months)
33. What are the Sources of credit? a. Service cooperative b. Commercial banks c. Friends e Other__________
34. If no why? a. Lack of access to credit b. No need for credit c. High interest rate d. Other___________________

Section six: Household Expenditures (Food and Non-food consumption Expenditure)

Variable codes

1=Teff 2= Barley 3= Wheat 4= Maize 5= Sorghum 6= Rice 7= Lentils 8= Faba bean= 9 Field peas 10= Chick peas 11= Guaya 12= Linseed 13=Sesame 14= Sun flower 15= Tella 16= Arequi 17= Teji 18= Beer 19= Coffee 20= Honey 21= Sugar 22= Tea 23= Berbere 24= Salt 25= Onion 26= Bread 27= Macaroni 28= Potato 29= Tomatoes 30 = Carot 31= Karia 32= Gomen 33= Banana 34= Zeytihun 35= Cheese 36= Butter 37= Beef meat 38=Chicken 39=Eggs… 50=Others

35. Indicate the type and amount of food expenditures of your family for the last one year in the following table by using the above variable codes

No	Food type code	Total food consumed			NO	Food type code	Total food consumed		
		Amount	Unit	Value(Birr)			Amount	Unit	Value(Birr)
1					22				
2					23				
3					24				
4					25				
5					26				
6					27				
7					28				
8					29				
9					30				
10					31				
11					32				
12					33				
13					34				
14					35				
15					36				
16					37				

17					38				
18					39				
19					40				
20					41				
Total									

Variable codes

1= Clothes/Shoes for Adults 2= Clothes/Shoes for Children 3= Energy consumption 4= Soap, Omo 5= Cosmetics (including butter) 6= Lines (sheets, towel, blankets) 7= Furniture and lamp 8= Transport materials 9= Building materials for house 10= Ceremonial expense 11= Contribution to social association 12= Donation to organization (TDA, TOLF, etc) 13= Taxes and contribution to Tabia 14= Medical treatment and medicine 15= School fees 16= Educational materials … 22= others

36. Would you indicate the household's non-food expenditure in the last one year (2005 E.C)?(Use the variable codes given above)

No	Item code	Total expenditure			No	Item code	Total expenditure		
		Amount	Unit	Value(Birr)			Amount	Unit	Value(Birr)
1					10				
2					11				
3					12				
4					13				
5					14				
6					15				
7					16				
8					17				
9					18				
Total									

37. Did you face food shortage during last one year? a. Yes b. No
38. If yes, during which months? ___________________________________
39. What do you think the main causes of food deficit in your particular area? a. Variability in rainfall b. Incidence of pest, diseases, weeds etc. c. Lack of access to credit d. Lack of appropriate extension support f. Other________

Section seven: General opinion

40. Please list all problems associated with irrigation development activities in your area:
    a.____
    b.____
41. Describe any social economic and environmental problems you have in the area.
    a.____
    b.____
42. Give your view as to what interventions must be made for better implementation of modern irrigation technologies.
    a.____

    b.____